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Agricultural Experiment Station

SOIL REPORT No. 28

MASON COUNTY SOILS

By R. S. SMITH, E. E. DE TURK, F. C. BAUER,
AND L. H. SMITH

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The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Mason county was conducted, and to Mr. A. F. Gustafson, now Extension Professor of Soil Technology at Cornell University, who was in direct charge of the field party in the construction of the map.

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MASON COUNTY SOILS

By R. S. SMITH, E. E. DE TURK, F. C. BAUER, AND L. H. SMITH[1]

LOCATION AND CLIMATE OF MASON COUNTY

Mason county is located just west of the central part of the state. It is a medium-sized county, embracing 554 square miles, 494 square miles of which consist of a glacial terrace formation.

The climate of Mason county is typical of the region. It is characterized by a wide range between the extremes of winter and summer and by an abundant, well-distributed rainfall. The greatest range in temperature for any one year from 1904 to 1923 was 128 degrees in 1914. The lowest temperature recorded was –26° in 1905 and 1914; the highest, 106° in 1911 and 1918. The average date of the last killing frost in the spring is April 22; the earliest in the fall, October 19. The average length of the growing season is 180 days.

The average annual rainfall as recorded at Havana from 1904 to 1923 was 32.92 inches. The average rainfall by months for this period was as follows: January, 2.13 inches; February, 1.50; March, 2.37; April, 3.68; May, 4.07; June, 3.37; July, 3.22; August, 2.86; September, 4.08; October, 2.02; November, 2.03; December, 1.47.

AGRICULTURAL PRODUCTION

Mason county is distinctly agricultural, but only about 60 square miles of the 554 making up the county is typical of the corn belt. Something over 20 percent of the area of the county is so sandy as to be of lower agricultural value than the soils commonly occurring in the corn belt. According to the Fourteenth Census of the United States, there were 1,558 farms in 1920. The average acreage per farm was 199.9, 172.7 acres of which were improved. The number of farms has decreased at the rate of about 100 every ten years for the last two decades. This rate of decrease is exceeded by many counties in the state. Of these 1,558 farms, 60.5 percent were operated by tenants in 1920, which is a slight decrease in tenantry in the last twenty years.

The principal crops are corn, oats, wheat, rye, and forage crops, including timothy, mixed clover and timothy, clover, alfalfa, silage crops, and corn cut for forage. The following table shows the acreage and yield of the more important crops for the year 1919, as given by the above mentioned census.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	82,731	2,680,066 bu.	32.4 bu.
Oats	24,771	552,279 bu.	22.3 bu.
Wheat	83,226	1,425,949 bu.	17.1 bu.
Rye	18,827	191,372 bu.	10.2 bu.
Timothy	1,884	2,301 tons	1.22 tons
Timothy and clover mixed	2,359	3,069 tons	1.30 tons
Clover	1,040	1,205 tons	1.16 tons
Alfalfa	1,724	4,160 tons	2.41 tons
Silage crops	745	3,887 tons	5.22 tons
Corn for forage	1,695	2,911 tons	1.72 tons

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

Mason county is not an important live-stock county. The total value of all live stock and live-stock products in 1919 was $3,408,320. The following figures taken from the 1920 Census show the character of the live-stock interests in Mason county.

Animals and Animal Products	*Number*	*Value*
Horses	9,518	$1,036,751
Mules	2,139	293,862
Beef Cattle	4,445	288,979
Dairy cattle	8,553	544,597
Swine	26,872	498,802
Poultry	162,971	158,221
Eggs and chickens	———	353,147
Dairy products	———	225,875

Fruit and vegetable growing are of very little importance in this county so far as commercial production is concerned.

SOIL FORMATION

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which the material that later formed the soils was being deposited. At that time, snow and ice accumulated in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains in great masses. These masses pushed outward from their centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced, it buried everything, even the highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered part of northern United States, altho the same parts were not covered during each advance.

In advancing from the distant northern centers of accumulation, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. Some of these materials were carried several hundred miles, and the coarser masses rubbed against the surface rocks or against each other until largely ground into rock powder, which now constitutes much of the soil material in Illinois.

A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were entirely changed. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was dropped along the front or side of the ice sheet and accumulated in a broad, undulating ridge or moraine, called a lateral moraine if formed at the side of the glacier and a terminal moraine if formed at the end. If the ice melted more rapidly than the glacier advanced, the

terminus of the glacier would recede, and the material would be deposited somewhat irregularly over the land back of the moraines. Such a formation is known as a ground moraine. A glacier often would advance again, but not so far as before, or it would remain stationary and another moraine would be built up. These moraines, or ridges, have a steep outward slope and a very gradual inward slope.

Only one of the great glacial advances, the Illinoisan, covered the area that now constitutes Mason county. This ice sheet, no doubt, did a great deal towards leveling the surface and covering it with till. The Iowan glacier, which covered only the northern part of the state, followed the Illinoisan glacier, and while it did not reach Mason county, yet it furnished large quantities of ground-up rock material which was carried south and deposited on the flood plains of the Illinois and Mississippi rivers. From here it was carried by the wind and deposited over the upland. This material is known as loess. Mason county received its share of this deposit.

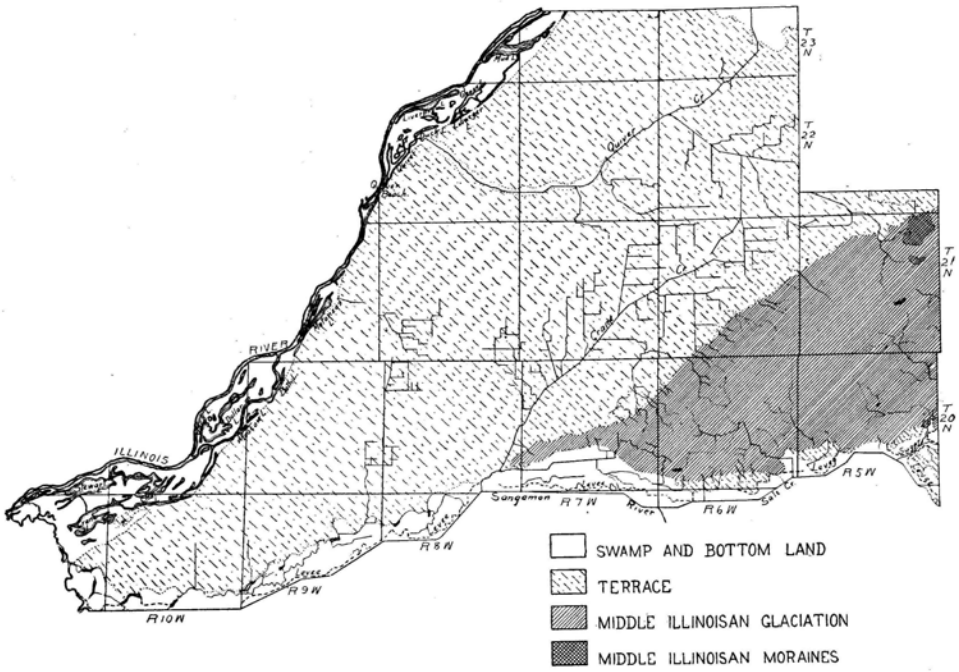
The ice of the Wisconsin glaciations, which followed the Iowan, did not reach Mason county, but the immense floods produced by the melting of these glaciers deposited large amounts of sand and gravel. The sand was later reworked by the wind, forming extensive sand dune areas. Some of it was carried to the eastward and deposited on the upland, forming a belt of upland sandy soil about four miles wide, extending in a northeast-southwest direction, with its eastern border passing thru Mason City.

PHYSIOGRAPHY AND DRAINAGE

Part of the water of Mackinaw river, and possibly of the Illinois, flowed across this county thru the Quiver creek valley, to Illinois river and thru the Crane creek valley into Sangamon river and thence into the Illinois. The lack of any distinct divide is shown by the fact that the dredge ditch of Quiver creek is continuous to Mackinaw river in Tazewell county. Dredge ditches connect the head waters of Crane and Quiver creeks.

A large part of Mason county was originally poorly drained. The central part was formerly occupied by extensive swamps and the Illinois bottom land is still swampy. These swampy conditions resulted in the formation of numerous areas of highly organic soils. A large area of peat occurs near Manito and smaller areas of peat or peaty material are found thruout the county excepting on the prairie south of San Jose. Quiver and Crane creeks are the principal natural drainage channels for the interior, while Salt creek and Sangamon river form the drainage for the south side of the county.

The western third of the county comprizes an area made up largely of sand or very sandy loam and with few exceptions the drainage of this area is good. Dredge ditches have been used to supplement the natural drainage over a considerable area in the central portion of the county. An area of about twelve sections extending north and south from Longbranch has been artificially drained. The upland part of the county comprizing that part east of Teheran is not very difficult to drain. Already over 200 miles of dredge ditches have been dug. In many cases a substratum of sand or gravel is found at a depth varying from four to ten feet, and this usually furnishes good natural drain-



MAP SHOWING THE DRAINAGE BASINS OF MASON COUNTY WITH MORAINAL, INTERMORAINAL, AND TERRACE AREAS

age. In some cases, holes are dug in the low places and filled with gravel, thus giving the water a chance to get into the coarse material beneath.

Many small ponds occur in the upland which may be drained most easily by vertical drainage. This system may be put in by boring down into sand or gravel with a post auger and putting in a 6-inch tile. The sand or gravel stratum will allow the water to escape. The drain-head should be covered so that the sediment cannot wash in. The vertical 6-inch tile is capped with a much larger tile, 12-inch, and extends up into the larger for three or four inches. The top of the larger tile should be covered with a heavy board or concrete slab and placed sufficiently deep so that when leveled it would be covered with 12 to 18 inches of soil.

The altitude of low water at Havana is 430 feet above sea level. The following are the altitudes of some of the railroad stations: Bath, 462 feet; Biggs, 501; Bishop, 490; Conover, 505; Easton, 512; Forest City, 486; Havana, 451; Kelsey, 494; Kilbourne, 495; Manito, 503; Matanzas, 465; Mason City, 581; Natrona, 576; Poplar City, 509; Quiver, 480; San Jose, 593; Saidora, 462; Teheran, 541; Topeka, 480.

SOIL TYPES

The soils of Mason county are divided into four groups, as follows:

(a) *Upland Prairie Soils,* usually rich in organic matter. These areas were originally covered with wild prairie grasses, the partially decayed roots of which have been the chief source of their organic matter. Of the prairie soils, Dune Sand contains the least organic matter.

TABLE 1.—SOIL TYPES OF MASON COUNTY

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (200, 400, 800)			
460	Brown Sandy Loam	31.01	19,846	5.60
226, 426	Brown Silt Loam	18.03	11,539	3.25
826	Brown Silt Loam (loessial formation)	13.69	8,762	2.47
427	Brown Silt Loam Over Sand	8.03	5,139	1.45
428	Brown-Gray Silt Loam On Tight Clay	7.90	5,056	1.43
425.1	Black Silt Loam On Clay	2.61	1,670	.47
420	Black Clay Loam	.87	557	.16
481	Dune Sand	.66	422	.12
486	Fine Dune Sand	.63	403	.11
290, 490	Gravelly Loam	.09	58	.02
		83.52	53,452	15.08
	(b) Upland Timber Soils (400, 800)			
845	Yellow Fine Sandy Silt Loam	5.46	3,495	.99
844	Yellow-Gray Fine Sandy Silt Loam	1.96	1,255	.35
465	Yellow Sandy Loam	4.55	2,912	.82
464	Yellow-Gray Sandy Loam	1.88	1,203	.34
434	Yellow-Gray Silt Loam	.19	122	.03
		14.04	8,987	2.53
	(c) Terrace Soils (1500)			
1560	Brown Sandy Loam	126.82	81,165	22.89
1581	Dune Sand	113.81	72,839	20.54
1561	Black Sandy Loam	39.13	25,043	7.06
1568	Brown-Gray Sandy Loam On Tight Clay	30.02	19,213	5.42
1520	Black Clay Loam	9.08	5,811	1.64
1525	Black Silt Loam	10.56	6,758	1.91
1527	Brown Silt Loam Over Sand or Gravel	15.76	10,087	2.84
1564.2	Yellow-Gray Sandy Loam On Sand	11.95	7,648	2.16
1528	Brown-Gray Silt Loam On Tight Clay	4.19	2,682	.76
1586	Fine Dune Sand	2.78	1,779	.50
1534	Yellow-Gray Silt Loam	1.26	806	.23
		365.36	233,831	65.95
	(d) Swamp and Bottom-Land Soils (1400)			
1426	Deep Brown Silt Loam	16.21	10,374	2.93
1454	Mixed Loam	44.24	28,314	7.98
1421	Drab Clay Loam	7.30	4,672	1.32
1401	Deep Peat	3.57	2,285	.64
1402	Medium Peat On Clay	.84	538	.15
1410.2	Peaty Loam On Sand	2.96	1,894	.53
1413	Clayey Muck	.26	166	.05
1475	Yellow Fine Sandy Loam	1.18	755	.21
1460	Brown Sandy Loam	3.48	2,227	.63
1480	Alluvial Sand	.25	160	.05
		80.29	51,385	14.49
	Water	10.78	6,899	1.95
	Total	553.99	354,554	100.00

(b) *Upland Timber Soils,* including those soils often found along stream courses over which forests grew for a long period of time. As a class, these soils contain much less organic matter than those of the prairie, because the large roots of dead trees and the surface accumulations of leaves, twigs, and fallen

trees suffered almost complete decay or were burned by forest fires. The timber soils are divided chiefly into two subgroups—the undulating and the hilly areas.

(c) *Terrace Soils,* formed by deposits from flooded streams overloaded with sediment at the time of the melting of the glaciers. Finer deposits which were later made upon the coarse, gravelly material now constitute the soil. Large quantities of sand deposited and reworked by the wind give rise to dune areas.

(d) *Swamp and Bottom-Land Soils,* which include the flood plains along streams and some poorly drained and peaty swamp areas.

Table 1 gives the area of each type of soil in Mason county and its percentage of the total area. It will be observed that 15.08 percent of the county consists of upland prairie, 2.53 percent of upland timber, 65.95 percent of terrace soils, and 14.49 percent of swamp and bottom-land soils. The accompanying map, appearing in two sections, shows the location and boundary lines of the various types.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this report.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN MASON COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose, samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2,000,000 pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata, respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and the distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types as surface, subsurface, and subsoil. By this system of sampling, we have represented separately three zones for plant feeding. The upper, or surface layer includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of equal importance, is governed by many factors.

For convenience in making application of the chemical analyses the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this, the assumption

is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2,000,000 pounds, exceptions being made of certain soils very high in organic matter, such as the peats and the mucks. It is understood, of course, that this value is only an approximation but it is believed that, with this understanding, it will suffice for the purposes intended. It is a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amount of organic carbon (which serves as a measure of the total organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in Mason county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity in the different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages in the respective types. In examining each soil type in the field, however, numberous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussions of the individual soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime-requirement may change from time to time, especially under cropping and treatment. Therefore, it is usually desirable to determine the lime-requirement for a given field and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 39).

In connection with Table 2, it is of interest to note the variation among the different soil types with respect to their content of the various plant-food elements. It will be seen from the analyses that variations in the organic-carbon content of the different soils are accompanied by similar variations in the nitrogen content. (The organic-carbon content is usually from 10 to 14 times that of total nitrogen.) This close relationship is explained by the well established facts that all soil organic matter contains nitrogen and that most of the soil nitrogen (usually 99 percent or more) is present in a state of organic combination. Such a consistent relationship, which is also maintained in the middle and lower sampling strata, is not to be observed between any of the other elements. A less marked, tho positive correlation, exists with respect to sulfur and organic matter. The organic matter with its nitrogen exhibits extreme variations in amount in the different soils of the county because of the presence both of peaty soils, which are composed mainly of organic matter, and of sands, which are characteristically deficient in it. The smallest amounts of organic carbon and nitrogen are found in Dune Sand and Alluvial Sand. The Alluvial Sand (to a depth of 6⅔ inches) contains 3,380 pounds of organic carbon per acre and 260 pounds of nitrogen. The largest amounts of both organic carbon and nitrogen are found in Deep Peat, which contains 440,880 pounds of organic carbon and 35,100 pounds of total nitrogen in one million pounds of the upper stratum (0 to 6⅔

inches). The carbon thus amounts to 44 percent of the soil and since organic matter is about half carbon, this soil consists of approximately 88 percent of organic matter. On the basis of the 6⅔-inch stratum, Deep Peat contains about 130 times as much organic matter and nitrogen as Alluvial Sand.

The large proportion of sandy soils in Mason county, 67.79 percent of the entire area, makes a consideration of these soil types of particular importance. The average organic-carbon content of these soils, including sixteen soil types, is 19,920 pounds per acre in the upper 6⅔ inches while the nitrogen content averages 1,610 pounds. These amounts are very low, being only about two-fifths as much as the quantities of these two elements present in the fifteen silt loam and clay loam types, which amount to 50,240 pounds of carbon and 4,350 pounds of nitrogen per acre. The loose, open character of sandy soils, which permits the ready access of air, encourages the rapid decomposition of organic materials thus making the maintenance of organic matter and nitrogen on such soils a particularly difficult problem. These considerations serve to emphasize the necessity of giving particular attention to the return of organic materials to soils of this group in planning crop rotations. The only sandy soil type in the county which is naturally well supplied with organic matter and nitrogen is the Black Sandy Loam.

It may be noted that the timber soils, as a rule, are light in color (yellow or yellowish gray) and are also rather poorly supplied with organic matter and nitrogen; while the prairie soils, which are generally brown or black in color, contain much larger quantities of these two materials.

With the exception of the nitrogen, sulphur, and organic-matter correlations previously mentioned, the elements vary independently and within a fairly wide range as a rule. Thus the phosphorus content varies from 440 pounds per acre in Dune Sand, Terrace, and in Yellow Sandy Loam, to 3,420 pounds in Clayey Muck, Bottom. Magnesium ranges from 2,340 pounds in Dune Sand, Upland, to a maximum of 31,860 pounds in Black Silt Loam, while total calcium ranges from 3,920 pounds in Dune Sand to 163,860 in Clayey Muck. The extremely large amounts of calcium are accounted for by the presence in the soil of calcium carbonate (limestone). The potassium content of all the soils is fairly constant between 25,000 and 35,000 pounds per acre, with the exception of the soils containing very large amounts of organic matter, particularly the peaty soils. The peaty soils, containing as low as 2,930 pounds of potassium per acre, are so markedly deficient in this element as to make potassium fertilization very frequently a necessity for successful crop production.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper one, it will be noted that in the majority of soil types the proportion of organic-matter and nitrogen diminish rather rapidly with increasing depth. On the other hand, the middle and lower strata contain as a rule practically as large a percentage of the mineral elements as the upper stratum. In thus making comparisons, on the basis of percentage, the data as given for the middle and lower

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF MASON COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
AVERAGE POUNDS PER ACRE IN 2 MILLION POUNDS OF SOIL

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400, 800)							
460	Brown Sandy Loam	22 850	1 860	740	310	31 010	5 150	6 910
426	Brown Silt Loam	49 180	4 020	1 100	580	36 300	7 540	8 160
826	Brown Silt Loam (Loessial)	42 740	3 680	1 060	680	37 080	8 480	9 020
427	Brown Silt Loam Over Sand	37 420	3 320	1 020	640	34 020	5 060	6 160
428	Brown-Gray Silt Loam On Tight Clay	57 680	7 000	1 500	920	36 720	5 720	7 560
425.1	Black Silt Loam On Clay	68 360	5 420	1 440	620	38 160	10 460	15 000
420	Black Clay Loam	81 600	6 040	1 680	1 140	34 900	12 260	21 220
481	Dune Sand	9 780	600	520	260	25 760	2 340	3 920
486	Fine Dune Sand	6 200	340	540	220	26 880	3 160	7 160
290	Gravelly Loam	14 980	1 200	700	400	22 040	5 100	5 400
	Upland Timber Soils (400, 800)							
845	Yellow Fine Sandy Silt Loam	27 780	2 380	680	340	34 860	5 140	8 640
844	Yellow-Gray Fine Sandy Silt Loam	24 420	2 180	780	420	35 600	6 640	8 020
465	Yellow Sandy Loam	10 540	920	440	220	30 520	4 580	8 260
464	Yellow-Gray Sandy Loam	15 020	1 080	480	220	33 460	4 020	8 200
434	Yellow-Gray Silt Loam	28 400	2 920	900	420	38 740	6 160	8 300
	Terrace Soils (1500)							
1560	Brown Sandy Loam	21 280	1 700	810	370	27 090	4 410	5 480
1581	Dune Sand	9 040	590	440	170	19 430	3 140	5 450
1561	Black Sandy Loam	50 560	4 160	1 440	720	21 220	8 040	13 940
1561	Black Sandy Loam (Alkali)	71 720	6 480	1 460	1 060	20 840	11 460	105 200
1568	Brown-Gray Sandy Loam On Tight Clay	22 370	1 930	650	360	31 210	3 460	6 110
1520	Black Clay Loam	113 080	8 760	1 720	1 780	25 720	14 720	26 920
1525	Black Silt Loam	55 280	5 180	1 660	820	33 060	31 860	51 580
1527	Brown Silt Loam Over Sand or Gravel	49 400	3 940	1 260	660	38 000	7 480	10 520
1564.2	Yellow-Gray Sandy Loam On Sand	11 260	900	540	200	28 320	3 160	4 960
1528	Brown-Gray Silt Loam On Tight Clay	32 940	2 760	840	500	34 180	5 760	9 080
1586	Fine Dune Sand	11 080	820	480	240	23 300	3 220	6 480
1534	Yellow-Gray Silt Loam	26 400	2 480	900	420	38 920	6 220	7 660
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	44 240	4 360	1 960	700	38 240	13 760	15 200
1454	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1421	Drab Clay Loam	51 900	4 240	1 760	880	39 740	15 760	15 300
1401	Deep Peat[2]	440 880	35 100	1 820	5 250	2 930	4 060	34 440
1402	Medium Peat On Clay[2]	370 960	30 150	1 830	4 280	5 040	3 380	27 880
1410.2	Peaty Loam On Sand[3]	144 600	10 180	2 470	1 490	14 890	4 900	19 130
1413	Clayey Muck[3]	201 800	18 530	3 420	2 880	12 770	8 640	163 860
1475	Yellow Fine Sandy Loam	14 780	1 500	1 120	300	36 820	19 280	30 200
1460	Brown Sandy Loam	38 040	3 360	1 360	700	32 300	10 840	13 360
1480	Alluvial Sand	3 380	260	640	140	25 420	12 080	24 180

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1] On account of the heterogeneous character of the Mixed Loam, chemical analyses are not included for this type.

[2] Amounts reported are for 1 million pounds of Deep Peat and Medium Peat on Clay.

[3] Amounts reported are for 1½ million pounds of Peaty Loam On Sand and Clayey Muck.

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF MASON COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
AVERAGE POUNDS PER ACRE IN 4 MILLION POUNDS OF SOIL

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400, 800)							
460	Brown Sandy Loam	43 100	3 840	1 580	860	63 220	11 820	14 280
426	Brown Silt Loam	75 200	6 880	2 120	1 120	75 280	18 120	17 840
826	Brown Silt Loam (Loessial)	68 040	6 320	2 080	1 160	76 960	19 880	18 160
427	Brown Silt Loam Over Sand	66 480	5 960	1 800	1 200	68 560	15 440	11 760
428	Brown-Gray Silt Loam On Tight Clay	32 720	3 600	1 880	560	79 640	10 440	14 880
425.1	Black Silt Loam On Clay	96 880	7 840	2 320	880	77 880	22 200	31 200
420	Black Clay Loam	95 400	6 960	2 520	1 760	68 920	28 840	43 040
481	Dune Sand	14 800	720	1 040	480	50 000	4 120	8 320
486	Fine Dune Sand	9 320	480	960	440	54 520	7 000	10 400
290	Gravelly Loam	22 760	1 920	1 200	920	43 720	10 280	9 360
	Upland Timber Soils (400, 800)							
845	Yellow Fine Sandy Silt Loam	17 120	2 000	1 400	360	73 080	16 880	15 080
844	Yellow-Gray Fine Sandy Silt Loam	22 040	2 600	1 560	600	71 960	23 200	13 240
465	Yellow Sandy Loam	11 880	1 160	880	440	63 040	10 080	14 840
464	Yellow-Gray Sandy Loam	13 160	1 360	920	440	68 040	9 200	15 920
434	Yellow-Gray Silt Loam	21 600	2 440	2 080	440	80 160	21 920	14 760
	Terrace Soils (1500)							
1560	Brown Sandy Loam	42 250	3 530	1 690	830	55 240	9 780	11 310
1581	Dune Sand	9 040	680	820	230	39 050	6 280	10 570
1561	Black Sandy Loam	58 800	4 520	2 280	1 200	41 920	15 880	23 640
1561	Black Sandy Loam (Alkali)	88 200	8 360	2 360	1 240	43 080	21 600	183 400
1568	Brown-Gray Sandy Loam On Tight Clay	24 160	2 420	880	520	65 940	10 580	12 160
1520	Black Clay Loam	95 200	6 760	2 560	1 880	52 760	35 000	48 160
1525	Black Silt Loam	62 440	6 400	2 800	960	67 360	61 960	100 040
1527	Brown Silt Loam Over Sand or Gravel	71 120	6 280	2 120	1 040	79 200	18 640	17 160
1564.2	Yellow-Gray Sandy Loam On Sand	10 760	1 000	840	200	56 200	5 720	11 200
1528	Brown-Gray Silt Loam On Tight Clay	38 720	3 760	1 200	640	71 720	15 840	18 840
1586	Fine Dune Sand	11 320	840	760	240	49 120	6 240	11 760
1534	Yellow-Gray Silt Loam	21 320	2 520	1 560	440	82 680	19 680	13 400
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	83 280	7 280	3 040	1 560	71 760	27 160	29 080
1454	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1421	Drab Clay Loam	66 240	6 200	2 280	1 560	76 080	30 200	28 480
1401	Deep Peat[2]	854 620	65 780	2 170	11 000	5 510	9 610	68 220
1402	Medium Peat On Clay[2]	486 440	32 640	1 860	5 960	21 720	9 620	38 280
1410.2	Peaty Loam On Sand[3]	143 470	8 280	2 000	1 400	38 460	10 460	26 160
1413	Clayey Muck[3]	391 650	28 860	5 400	4 290	34 710	15 960	143 490
1475	Yellow Fine Sandy Loam	39 160	3 800	2 160	560	74 720	29 200	47 280
1460	Brown Sandy Loam	44 680	4 160	1 840	960	60 040	18 400	23 360
1480	Alluvial Sand	4 640	360	960	240	51 440	25 440	52 280

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1] On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

[2] Amounts reported are for 2 million pounds of Deep Peat and Medium Peat On Clay.

[3] Amounts reported are for 3 million pounds of Peaty Loam On Sand and Clayey Muck.

sampling strata should be divided by two and three respectively.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is impossible to obtain this information

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF MASON COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES
AVERAGE POUNDS PER ACRE IN 6 MILLION POUNDS OF SOIL

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400, 800)							
460	Brown Sandy Loam	34 350	3 330	1 950	900	94 140	20 190	20 490
426	Brown Silt Loam	68 580	6 300	2 400	1 020	118 560	33 180	24 600
826	Brown Silt Loam (Loessial)	66 000	6 060	2 940	1 440	117 240	37 680	28 020
427	Brown Silt Loam Over Sand	47 820	4 200	2 280	1 320	105 480	26 640	14 940
428	Brown-Gray Silt Loam On Tight Clay	19 320	2 400	3 120	780	120 720	25 860	30 540
425.1	Black Silt Loam On Clay	58 560	4 680	2 880	540	115 140	46 560	49 320
420	Black Clay Loam	107 940	3 660	2 940	2 160	84 360	115 140	451 080
481	Dune Sand	9 360	780	1 560	600	77 460	8 220	16 560
486	Fine Dune Sand	10 200	900	1 980	600	90 780	19 320	21 180
290	Gravelly Loam	19 800	1 400	1 620	960	62 940	14 340	13 380
	Upland Timber Soils (400, 800)							
845	Yellow Fine Sandy Silt Loam	24 720	2 760	2 880	900	105 000	38 400	24 120
844	Yellow-Gray Fine Sandy Silt Loam	22 140	2 880	2 400	1 020	107 940	40 860	21 600
465	Yellow Sandy Loam	14 940	1 980	1 740	660	98 160	22 320	22 440
464	Yellow-Gray Sandy Loam	19 140	2 400	2 220	900	105 960	34 440	22 140
434	Yellow-Gray Silt Loam	17 820	2 520	3 660	480	119 580	45 300	22 920
	Terrace Soils (1500)							
1560	Brown Sandy Loam	38 160	3 350	2 150	1 250	80 540	16 730	15 290
1581	Dune Sand	11 160	900	1 170	450	58 800	9 500	16 050
1561	Black Sandy Loam	52 800	3 660	4 020	600	66 420	26 400	47 000
1561	Black Sandy Loam (Alkali)	52 620	4 500	3 360	1 020	76 920	31 020	76 320
1568	Brown-Gray Sandy Loam On Tight Clay	23 370	2 460	1 890	810	96 330	24 180	21 360
1520	Black Clay Loam	70 020	4 500	3 900	1 980	87 840	91 980	340 380
1525	Black Silt Loam	43 500	4 080	3 240	1 320	103 560	96 840	149 220
1527	Brown Silt Loam Over Sand or Gravel	65 220	5 460	2 700	1 200	113 400	40 200	24 960
1564.2	Yellow-Gray Sandy Loam On Sand	12 180	1 320	1 800	240	84 180	12 360	15 540
1528	Brown-Gray Silt Loam On Tight Clay	34 020	3 300	2 340	900	102 360	45 420	35 880
1586	Fine Dune Sand	11 520	960	1 260	420	73 140	10 620	18 060
1534	Yellow-Gray Silt Loam	25 440	3 360	3 120	600	119 520	44 160	21 420
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	75 720	6 300	3 180	1 260	105 000	34 440	39 480
1454	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1421	Drab Clay Loam	56 760	5 100	2 280	1 680	111 840	45 420	38 100
1401	Deep Peat[2]	1 293 030	93 210	2 910	14 360	10 250	14 360	99 560
1402	Medium Peat On Clay[3]	238 640	17 460	2 210	14 040	97 380	35 780	46 670
1410.2	Peaty Loam On Sand	46 140	1 980	1 650	6 870	86 760	32 130	56 040
1413	Clayey Muck[3]	140 220	8 550	1 940	2 430	74 880	22 500	49 450
1475	Yellow Fine Sandy Loam	84 360	7 260	3 720	960	109 620	30 360	50 520
1460	Brown Sandy Loam	31 620	3 000	2 040	1 020	88 800	26 820	32 280
1480	Alluvial Sand	14 100	1 140	1 560	300	86 640	40 140	81 480

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1] On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

[2] Amounts reported are for 3 million pounds of Deep Peat.

[3] Amounts reported are for 4½ million pounds of Medium Peat On Clay and Clayey Muck.

exactly, especially for the deeper-rooted crops, it seems probable that most of the feeding range of the roots of the majority of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type,

the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

A wide range of variation with respect to composition is found to occur in the sub-layers as well as in the top layer of the various soil types. The tables reveal further that there is not only this wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type, as measured by crop requirements. For example, in the most extensive soil type in the county, Brown Sandy Loam, Terrace, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 8,580 pounds. This is about the amount of nitrogen contained in 8,580 bushels of corn. The amount of phosphorus, 4,650 pounds, contained in the same soil is equivalent to that contained in 27,300 bushels of corn, while in the same quantity of this soil, there is present 162,870 pounds of potassium, the equivalent of that contained in 860,000 bushels of corn. In marked contrast to this soil is the Deep Peat, which contains in the 40-inch stratum approximately 194,000 pounds per acre of nitrogen, an amount equal to that in 194,000 bushels of corn. The phosphorus content is 6,900 pounds, or the equivalent of 40,600 bushels of corn, while the total amount of potassium is only 18,690 pounds, equivalent to 98,000 bushels of corn.

These statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration, aside from the mere amount of plant-food elements present in the soil. Much depends upon the nature of the crops to be grown as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way these chemical data contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Mason county occupy 83.52 square miles, or 15.08 percent of the area of the county. They occur in the eastern part of the county east of the line running northeast and southwest thru Teheran.

The dark color of prairie soils is due to the accumulation of organic matter, which is derived very largely from the fibrous roots of prairie grasses. The network of grass roots was protected from rapid and complete decay owing to the rather effective exclusion of oxygen by the covering of fine, moist soil, and by the mat of vegetative material formed by old grass stems and leaves. On the native prairies the stems and leaves of the grasses were, in part, burned by

prairie fires or were lost in part thru decay, so that they actually added little organic matter to the soil; however, the protection afforded by this mat of constantly renewed decaying material was of importance in retarding the decay of the roots. From a sample of virgin bluestem sod, one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of 7 inches may contain as high as 13½ tons of roots.

Brown Sandy Loam (460)

Brown Sandy Loam is the most extensive of the upland types in Mason county and occurs principally in a belt about five miles wide bordering the edge of the terrace which runs thru Teheran. Its presence in this border belt is due largely, if not entirely, to the movement of sand by the wind from the terrace on to the upland. It is possible that during periods of high water some of the sand in the low places may have been deposited as alluvial sand. Brown Sandy Loam, Upland, covers an area of 31.01 square miles, or 5.60 percent of the area of the county. Topographically, practically all of the area varies from undulating to rolling, and in some places erosion is doing considerable damage. Even tho the type is rather porous, the rolling character of the land gives the surplus water or run-off a chance to do a great deal of damage by erosion. The tendency to erode in spite of the porosity of the soil is due to its incoherent nature.

The surface soil, which is about 8 inches deep, is a brown to grayish brown sandy loam. Areas of Dune Sand which are too small to be shown on the map frequently occur. Brown Sandy Loam as it occurs in this county is very low in organic matter for a prairie type. The subsurface is from 5 to 10 inches in thickness. It varies in color from brownish yellow to yellow, and in physical composition from a loam to a sand, altho a sandy loam subsurface is most frequently found. The subsoil, which is found at a depth of 13 to 18 inches, is yellow in color and varies from sandy silt to almost pure sand. It is only slightly compact and shows very good aeration.

Management.—The organic-matter and nitrogen contents of this type are comparatively low, and in its management the maintenance and increase of these constituents are most important. This type shows considerable variation in lime requirement, but as a rule about 2 tons of limestone per acre are needed for the growth of clovers, which are necessary for maintaining the nitrogen. Red, mammoth, or sweet clover are the best kinds to grow. Cowpeas may be grown on the extreme sandy phases to good advantage. The phosphorus content of this type is not high; however the permeability of soil of this kind permits deep rooting and thus increases the feeding range of the roots to such an extent that in reality large quantities of phosphorus are within the feeding zone.

One of the greatest difficulties in the management of this type is the prevention of gullying. The subsoil is rather incoherent, and where a waterfall gully starts, the undermining action of the falling water goes on very rapidly, thus forming a gully which is very difficult to stop. Probably one of the best means for preventing further damage when a gully is once started is by means of straw dams held in place by woven or barb wire fences crosswise of the gully. It may be necessary in some cases to use a double fence, placing the lines about three feet apart. The space between the fences is filled with straw, making an effective

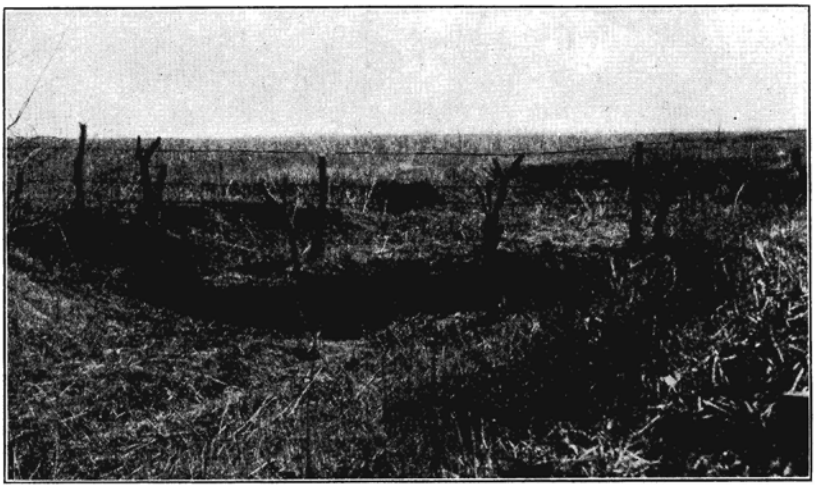


FIG. 1.—DAMS OF STRAW HELD BY WOVEN WIRE FENCING

dam. Concrete dams may be used but they are very expensive, and are no more effective than the straw dam. It is very necessary in the construction of either straw or concrete dams to guard against the water cutting around the ends of the dam. The cheapness of straw dams permits the use of large numbers, and if necessary, they can be placed every few rods to prevent washing and also to encourage the filling of the gully. Earth dams may be used to good advantage. An opening should be made into a tile above the dam so the water will not run

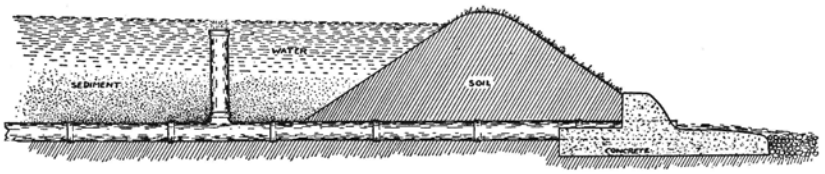


FIG. 2.—DAM OF EARTH

over it and wash it out. The diagram shows the construction of the dam and the location of the tile. Great care should be exercised in plowing up draws. It would be much better to sod them down permanently. This is practiced in some localities with excellent success.

Brown Silt Loam (426)

The upland Brown Silt Loam occurs principally in the two eastern townships, and covers an area of 18.03 square miles, or 3.25 percent of the area of the county. This type occupies slightly undulating to rolling areas of the prairie land. Most of it is well surface-drained, but some areas require artificial drainage.

The surface soil, which is about 9 inches deep, is predominantly a brown silt loam containing more than the usual amount of sand. It varies, however, from black as it grades into Black Clay Loam or Black Silt Loam, to light brown as it grades into Brown Sandy Loam. The subsurface extends to a depth of 18 to 22 inches and varies from brownish yellow to yellow silt loam. The subsoil,

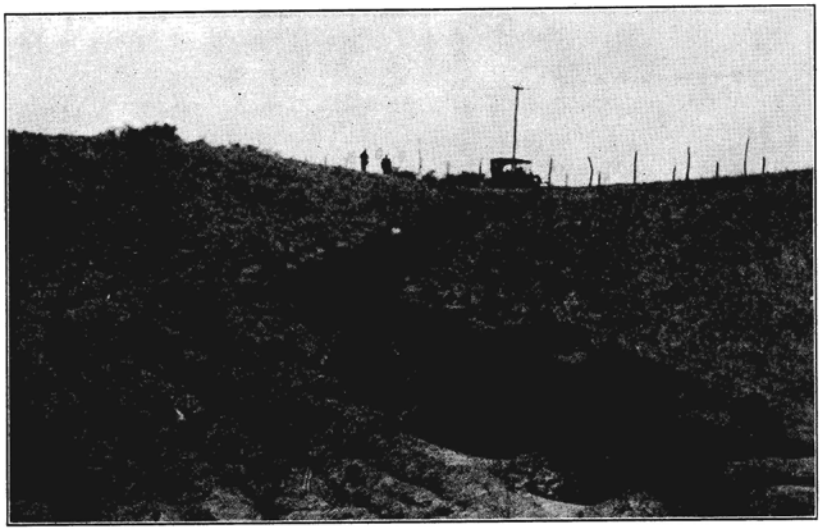


FIG. 3.—A SODDED DRAW AFTER PLOWING THE FIELD

beginning at a depth of 18 to 22 inches, is a fairly compact yellow silt loam or clayey silt loam with enough fine sand to prevent the development of high plasticity.

Management.—This type is readily pervious to air and water, and underdrainage is a comparatively easy matter where a good outlet can be obtained. The type shows a slight to medium acidity, the degree of acidity being about the same as in Brown Sandy Loam (460). Applications of limestone of about 2 tons per acre are necessary before best results can be secured with the clovers, altho alsike clover does well and red clover fairly well without lime on

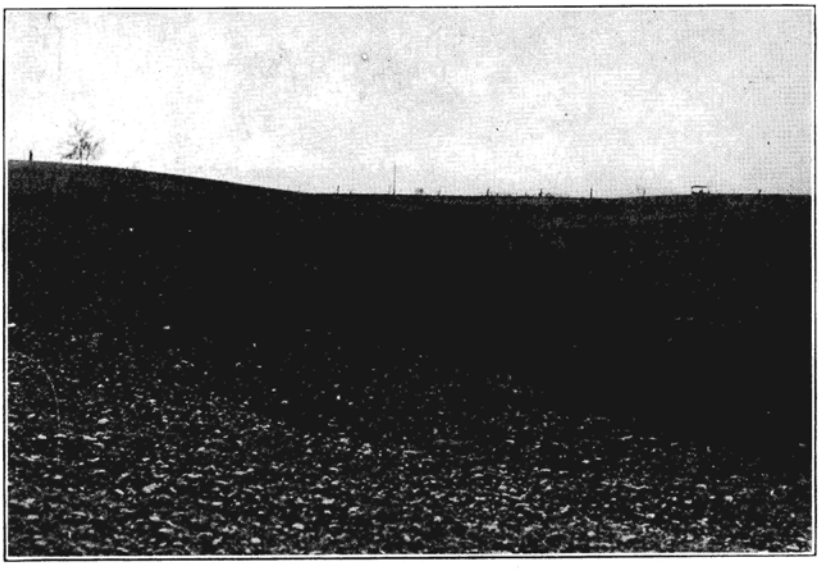


FIG. 4.—FIELD SHOWN IN FIGURE 3 AFTER PREPARING FOR PLANTING

much of the area. The same precautions are necessary in regard to the turning under of legumes and crop residues as for Brown Sandy Loam. The phosphorus content of this type is fairly high. The results from experiment fields located on similar soil seem to indicate that it is questionable whether rock phosphate when used at the rate of one ton per acre every four years in connection with limestone and manure or crop residues will increase yields sufficiently to pay for its cost. No information is available as to whether lighter applications of this material would prove profitable or not. Results from the Bloomington experiment field which is located on similar soil show a good profit from the use of steamed bone meal at the rate of 200 pounds per acre every year. Sufficient data are not available regarding acid phosphate to justify making any recommendation either for or against its use on this type of soil. If either steamed bone meal or acid phosphate is used, it should be applied broadcast after plowing for wheat, and thoroly worked in during the preparation of the seed bed, or else drilled in at the time of, or just before, drilling the wheat.

Suggestions for practical systems of cropping will be found in the discussion of crop rotations in the Appendix, on page 46. For the results of field experiments on this type of soil, see page 51 of the Supplement.

Brown Silt Loam (826) (Deep Loess Area)

Brown Silt Loam of the deep loess area occurs in the southeastern part of the county where deep wind deposits have been formed by fine material carried from the bottom land along Salt creek and the Sangamon river. The topography of this type is rolling and somewhat similar to that of dune formation. The type covers an area of 13.69 square miles, or 2.47 percent of the area of the county.

The surface soil, which is about 8 inches deep, is a brown silt loam containing nearly enough fine sand to be classed as a fine sandy loam. The subsurface extends to a depth of about 20 inches and is a yellowish brown fine sandy silt loam. The subsoil is a yellow silty clay loam and is compact, tho not impervious. This compact condition is less pronounced as the northern boundary of the type is approached.

Management.—This type requires the same management as Brown Silt Loam (426). It is, however, better drained naturally because of rolling topography, altho in the flatter portion of the area in the vicinity of Mason City underdrainage is necessary and, as a general rule, it is probably more in need of limestone than is Brown Silt Loam (426).

Brown Silt Loam Over Sand (427)

Brown Silt Loam Over Sand occurs principally in the area of Brown Sandy Loam. The sand is found at various depths from 3 to 6 feet. The type generally occupies the lower and flatter areas, but there are exceptions to this rule. The total area of the type is 8.03 square miles, or 1.45 percent of the area of the county. The topography is flat to slightly rolling, being distinctly dune-like in some places.

The surface soil, which is about 8 inches in depth, is a brown silt loam containing a fairly good supply of organic matter in the lower and flatter areas,

while in the higher more rolling areas the organic-matter content is relatively low, as indicated by the light brown color. The sand content of the surface soil of the type varies considerably and is, in general, higher than that usually found in silt loams. Numerous low mounds occur thruout the area of this type which were undoubtedly formed as dunes. These mounds are sandy loam rather than silt loam, but they are not large enough to be shown as separate types on the map. The subsurface is a light brown to yellowish brown silt loam 6 to 18 inches in thickness, varying in texture in the same way as the surface soil. The subsoil is a yellow silty material containing a considerable amount of fine sand.

Management.—All strata are pervious to water, and drainage is comparatively easy. Very little artificial drainage is necessary because of the sand subsoil. The same treatment should be applied to this type as to the Brown Silt Loam (426).

Brown-Gray Silt Loam On Tight Clay (428)

Brown-Gray Silt Loam On Tight Clay is very irregularly distributed over the upland. It is frequently found in the low undrained areas in the Brown Sandy Loam. Small ponds sometimes occur in these areas. The type covers an area of 7.90 square miles, or 1.43 percent of the area of the county.

The surface soil, which is 7 to 10 inches in depth, is usually a grayish brown silt loam containing more sand than is ordinarily found in a silt loam. The subsurface, which is 6 to 10 inches in thickness, is a gray or almost white silty or fine sandy material. This passes very abruptly into a mottled yellow or mottled drab clay, which is very plastic and impervious. This impervious stratum is usually about 12 inches thick and rests on a very friable, mottled yellow silty or fine sandy material.

Management.—This soil is acid; and about 3 to 4 tons of limestone should be applied as an initial application with subsequent applications of about 2 tons per acre when needed, as indicated by clover growth. This type is well supplied with all the elements of plant food. Much of the organic matter which is present in larger amounts than is usual for this type has reached the resistant stage in its decay. It is necessary, for this reason, to make systematic additions of fresh organic matter if the soil is to respond as it should to good tillage methods. The greatest natural difficulty encountered in the economical and efficient management of this type is poor drainage. The presence of the tight clay subsoil makes tiling expensive because the strings must be placed closer together than in more open subsoils and there is always the uncertainty as to whether the tile will draw with sufficient rapidity to be effective. Surface drainage, tho not entirely satisfactory, has to be depended on to a large extent for this type of soil.

Black Silt Loam On Clay (425.1)

Black Silt Loam On Clay occurs in the upland, associated with Brown Silt Loam, and usually occupies depressions, probably where Black Clay Loam has been buried by silty material washed in from the upland. It covers an area of 2.61 square miles, or .47 percent of the area of the county.

The surface soil, which is 8 to 12 inches in depth, is a black clayey silt loam, varying to a black silt or black sandy silt loam. It is well supplied with organic

matter. The subsurface consists of a stratum about 12 inches in thickness and varies from a black clayey silt loam to a black clay, usually becoming drabbish in color with increasing depth. The subsoil consists of a mottled yellowish drab or olive colored clay, varying to a yellow clay in local patches.

Management.—This type is becoming slightly acid in the surface in some areas. Carbonate, however, is usually found at a depth of 30 to 40 inches. It is well supplied with phosphorus and all of the other elements of plant food. The most important considerations in the management of this type are to provide good underdrainage and to maintain the organic-matter and nitrogen contents. Limestone is now needed on some of the areas, and as time goes on, areas not now needing this material will become acid.

Black Clay Loam (420)

Black Clay Loam, from the standpoint of area, is an unimportant type in Mason county. The total area covered by this type is only .87 square mile, or .16 percent of the area of the county. It occupies low areas in the upland.

The surface soil, which is about 9 inches in depth, is a black, granular, plastic clay loam. It is well supplied with organic matter. The subsurface is about 10 inches in thickness and varies from a black clay loam to a yellowish drab or olive color. The subsoil is a mottled drab or yellowish drab clay.

Management.—Under-drainage is the first requirement of this type, and this, together with good cultivation and the growing of legume crops and turning under of residues to maintain good tilth, are all the considerations necessary in its management. All strata contain more or less limestone.

Dune Sand (481)

The upland Dune Sand occurs principally within a distance of five miles from the edge of the terrace. It is present on the upland largely thru the action of wind which carried sand from the terrace. The dunes are very irregular in their distribution and shape. This type covers an area of .66 square mile, or .12 percent of the area of the county.

The surface consists of a light brownish yellow, incoherent sand, which is very low in organic matter. There is no distinct subsurface and subsoil development. There is no change with depth excepting that the color is yellow below about 7 inches.

Management.—(See also Management of Dune Sand, Terrace, page 22). The acidity of this type varies from slight to strong. No carbonates are present to a depth of 40 inches, tho the degree of acidity frequently decreases with depth. Two tons of limestone per acre is sufficient for the growth of sweet clover excepting on the most acid areas where 3 or even 4 tons may be required. This type, after treatment with limestone, will grow good sweet clover. Following sweet clover, bluegrass will do fairly well. The type is very low in nitrogen. It is also low in phosphorus and sulfur, and probably in available potassium. Limestone on the Oquawka field, which is located on similar soil, (see page 58 of the Supplement) has given very good returns; manure alone has not been very effective, but where a combination of either limestone and manure or limestone and crop

residues was used, very good increases in crop yields have resulted. This soil is so low in nitrogen that a rotation containing a liberal proportion of legumes should be adopted and the legumes should be used very largely for soil improvement. After the nitrogen deficiency has been satisfied in part, the use of 125 pounds of steamed bone meal or 250 pounds of acid phosphate per acre for wheat or rye, might prove profitable. A considerable proportion of this type is now in timber and this use of it should be encouraged.

Fine Dune Sand (486)

Fine Dune Sand occurs in a very limited area in the southwest corner of Crane Creek Township, Township 20 North, Range 7 West, and covers an area of .63 square mile, or .11 percent of the area of the county. It has the typical dune topography and there is no question as to its wind origin.

The surface, to a depth of about 8 inches, is a yellow or brownish yellow fine sand, which is very low in organic matter. No distinct subsurface and subsoil development is discernible, the only change with increasing depth being a gradual disappearance of the brownish tint which is frequently present in the surface.

Management.—The type is very low in nitrogen, phosphorus and sulfur. While this is a more productive soil than Dune Sand, it should be treated in the manner recommended for that type.

Gravelly Loam (290)

Gravelly Loam occurs in four small areas, one just east of Natrona, two near San Jose, and a fourth in Section 7 of Salt Creek Township, Township 20 North, Range 6 West. These represent gravel kames or hills that were deposited by the glacier. They have very little agricultural value, but the gravel may be used in the building of roads.

(b) UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on or near somewhat steep morainal ridges. They are characterized by a yellowish gray color, due to their low organic-matter content. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forest invaded the prairies, two effects were produced: first, the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; second, the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result, the organic-matter content of the upland timber soils has been reduced until it is decidedly lower than that of the adjacent prairie land. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils of Mason county occupy altogether about 2½ percent of the area of the county.

Yellow Fine Sandy Silt Loam (845)

Yellow Fine Sandy Silt Loam occurs on the upland near the bottom land of Salt Creek. It was formed from fine sandy material which was blown up out of the adjacent bottom land. Owing to the original dune-like character, and the erosion which has taken place, this type is very rough in topography. It covers an area of 5.46 square miles, or .99 percent of the area of the county.

The surface, to a depth of 7 to 9 inches, is a yellowish brown to light brown, fine sandy loam, which is low in organic matter. The subsurface and subsoil differ but little from the surface. The color is yellow and in places a slightly clayey sandy silt loam is found at a depth of 30 to 36 inches, indicating the beginning of true subsoil development.

Management.—The type is low in organic matter, and the growing of legumes and the turning under of residues are very necessary in order to increase the nitrogen and organic-matter content. The soil is usually acid and requires the application of about 2 tons of limestone per acre to grow sweet clover. Carbonates are usually found at a depth of 30 or 40 inches. The type erodes very badly because of the incoherent, fine sandy material that is nearly always found at a depth of 38 to 45 inches. The water-fall form of erosion is very common. This form of erosion is very difficult to control. Probably the best method of control is by means of straw dams made by putting in a double barb wire fence about four feet apart and filling in between with straw, as explained on page 13. Surface washing is not a serious matter on this type, and can be controlled by the ordinary means of incorporating organic matter, growing cover crops, and using care in plowing so as not to have dead furrows extending up and down the hill. If this soil is cropped, it should receive the same management as Dune Sand; however, it is recommended that most of this land be used for pasture.

Yellow-Gray Fine Sandy Silt Loam (844)

Yellow-Gray Fine Sandy Silt Loam covers an area of 1.96 square miles, or .35 percent of the area of the county. It is found in the same region as the Yellow Fine Sandy Silt Loam, but a distinction is made because of the more rolling topography of the latter type.

The surface soil, which is 7 to 9 inches in depth, is a grayish yellow fine sandy loam, low in organic matter. The subsurface is 6 to 12 inches in thickness. It is a yellow or slightly grayish yellow fine sandy loam. The subsoil is usually a yellow clayey silt.

Management.—This type varies widely in acidity. In some places all strata are acid, while in others no acidity is found and no carbonates occur within 40 inches of the surface. In still other places, carbonates are found at a depth of 30 to 40 inches. This soil is low in nitrogen, sulfur, and phosphorus. A comprehensive plan for the management of this type should include: first, the application of limestone if needed and in the amounts needed as shown by detailed tests (see page 39 of the Appendix); second, the growing of clovers, particularly sweet clover, and using them largely for soil improvement; third, the plowing in of crop residues, corn stalks directly, and the straws preferably

in the form of manure; and fourth, the application of an available phosphate, either steamed bone meal or acid phosphate, immediately before seeding wheat. It is possible that after the foregoing treatment has been applied, the addition of about 100 pounds per acre of a potash salt for corn would be profitable. If acid phosphate is used, it should be applied at the rate of about 250 pounds per acre, while if steamed bone meal is used, it should be applied at the rate of about 125 pounds per acre.

Yellow Sandy Loam (465, 865)

Yellow Sandy Loam is not an important type because of its limited extent and low agricultural value. There are several isolated areas along the edge of the terrace and also along the bluffs of the Sangamon river and Salt creek. The exposure of sand in the latter place is due to erosion, while in the former it is due to the action of the wind. The total area covered by this type is 4.55 square miles, or .82 percent of the area of the county.

The surface is a yellow sandy loam which is very low in organic matter. There is little change with depth, either in texture or color.

Management.—The more rolling portions of the type should be kept in permanent pasture or timber, as they have very little agricultural value and will be very rapidly ruined by erosion if an attempt is made to farm them.

Yellow-Gray Sandy Loam (464)

Yellow-Gray Sandy Loam is undulating in topography and its distribution is similar to that of the preceding type. It covers an area of 1.88 square miles, or .34 percent of the area of the county.

The surface soil, which is about 7 inches in depth, is a grayish yellow sandy loam. It is low in organic matter. The subsurface is a yellow sandy loam, while the subsoil varies from a silty sand to almost pure sand.

Management.—This type is acid, tho the degree of acidity varies from slight to medium. It is a poorer agricultural soil than Yellow-Gray Fine Sandy Silt Loam (844), but the same recommendations apply that were made for the management of that type.

Yellow-Gray Silt Loam (434)

Yellow-Gray Silt Loam occurs along Prairie creek in the southeastern part of the county and covers only .19 square mile, or 122 acres.

The surface soil, which is about 8 inches in depth, is a grayish yellow silt loam, low in organic matter. The subsurface is a yellowish gray silt loam. The subsoil, which is a compact but not plastic, mottled, yellow silty clay loam, is found at a depth of 16 to 18 inches.

Management.—This type requires the same treatment recommended for Yellow-Gray Fine Sandy Silt Loam (844).

(c) TERRACE SOILS

Terrace soils are formed on terraces or old fills in valleys. The terraces owe their formation generally to the deposition of material from overloaded streams which became greatly enlarged and which flooded the valleys during the melting

of the glaciers. Sometimes these valleys were filled almost to the height of the upland. Later the streams cut down thru the fills and developed new bottom lands, or flood plains, at lower levels, leaving part of the old fills as terraces. The lowest and most recently formed bottom land is called first bottom. The higher land no longer flooded (or very rarely, at most) is generally designated as second bottom or terrace. Finer material later deposited on the sand and gravel of the fill constitutes the mineral portion of the soil. About two-thirds of the area of Mason county is covered by soils of the terrace group.

Brown Sandy Loam (1560)

Brown Sandy Loam, Terrace, is one of the most widely distributed types of the county. It occurs thruout the terrace area. In the more swampy parts of this area, the type occupies the higher places, while in the more sandy regions it is found in the low and more poorly drained places. In the latter case, it is mixed with large irregular areas of Dune Sand. The type covers an area of 126.82 square miles, or 22.89 percent of the area of the county.

The surface soil, which is 7 to 8 inches in depth, is a brown sandy loam low in organic matter. The proportion of sand in the surface soil varies rather widely so that this stratum varies from a sand to a loam. The subsurface is 4 to 16 inches in thickness and varies from a yellowish or grayish brown sand to a yellowish or grayish brown sandy loam. The subsoil varies from a yellow silty sand to a yellow sand. In some areas, as in Townships 22 and 23 North, Range 6 West, the subsoil is heavier than in the more sandy regions.

An interesting variation of the type is found in the southwest part of the county where recent wind action has covered the surface soil to a depth of 3 to 6 inches with sand. Beneath this is a good brown sandy loam stratum, 12 to 20 inches in thickness. Such areas were mapped as Brown Sandy Loam on the basis of productiveness, even tho the surface soil is sand. These areas are very irregular, and it was found impossible to map them satisfactorily.

Management.—This type is acid but varies considerably in degree of acidity. It is an excellent soil for alfalfa after the acidity has been corrected. The organic-matter and nitrogen contents are higher than those of Yellow-Gray Sandy Loam but they are still too low for a productive soil. The pervious character of the soil makes it doubtful whether any form of phosphate could be used at a profit if full use is made of green manures and crop residues. A good soil management program for this type, at least for the present, is the use of limestone in the amounts needed, as indicated by detailed tests; the liberal use of legumes, particularly sweet clover; and good tillage methods.

Dune Sand (1581)

Dune Sand, Terrace, is very widely distributed, but occurs most abundantly within a zone of six to ten miles from the Illinois river. This sand was deposited during the melting of the Wisconsin glaciers when a considerable portion of the present terrace area was under water. The wind re-worked this material, and the formation of the dune areas resulted. Dune Sand, Terrace, covers an area of 113.81 square miles, or 20.54 percent of the area of the county. At one time

a considerable part of this dune area was covered with timber which varied considerably in size of trees and in density of stand. In some cases scattering trees only of black oak occurred, while in others heavy forests of white and red oak were found. It was impossible to make separations of the prairie and timber sand, because there is such a small difference in the organic-matter content between the two, and where the forests have been removed, there is no other basis upon which the separation could be made. The topography of the area varies widely. Some of the dunes are 75 to 100 feet in height, while others may be only 5 or 10 feet. In still other places the area is almost level.

The surface soil is a brownish yellow loamy sand, of medium texture. This same material extends to well below 40 inches in depth with no change except that the color changes to yellow at a depth of about 8 inches. The organic-matter content of this type is very low.

Management.—The recommendations made for the management of Dune Sand of the upland apply equally well to the terrace Dune Sand altho the latter is much more subject to drifting because it occurs in larger areas and the sand particles are somewhat coarser.

To prevent the movement of sand by the wind, it is necessary to have wind breaks, to keep the soil covered with vegetation, or to incorporate organic matter. The latter two methods are really the only practical ways of preventing drifting. Every means should be used for increasing the organic-matter content and for keeping a cover crop on the soil during the larger part of the year. Small grains are better adapted to accomplish this than corn. The plants that are best adapted to sand dunes are legumes, which, to a very large extent, are independent of the nitrogen in the soil. It is interesting to note that a few legumes have adapted themselves to the sand to a remarkable degree. The common sensitive plant (Cassia chameachrista) is found growing in abundance, and many of the abandoned sand fields are being invaded by this plant. It makes a very luxuriant growth. The climbing wild bean (Strophostyles panciflora) is another legume that is growing very abundantly on sand areas. It reseeds itself without any difficulty, and wheat or rye fields are soon covered with a growth of this plant after the crop has been removed. In some cases, at least a ton to the acre is produced. It would seem that this plant might well be distributed over all of the sand areas, especially those that are likely to drift.

In this county there would be very little drifting of these sandy areas if they were left in their natural state. In many places the native vegetation has been destroyed by pasturing too closely or by cropping, thus giving the wind an opportunity to do its work. This results in the formation of "blow-outs," which are small areas from which the surface sand has been blown. The action of the wind may result in the ruin of the land if some protection is not applied. Wind erosion on this soil is as bad as water erosion on other soils. Sand possesses very little cohesion, and is therefore moved quite readily by the wind; but when organic matter is added, this acts as a feeble, yet sufficiently strong, binder to hold the particles together so that drifting is greatly lessened or entirely eliminated.

The cowpea and, to a less extent, the soybean are well adapted to growing on sand. They furnish a large amount of organic matter to hold the sand and

the necessary nitrogen for growing other crops if the crop is plowed down. Where wheat or rye is grown, the drill, with beans or peas, should follow the binder. Normally they will make sufficient growth to add a considerable supply of organic matter and protect the soil during the winter. If the land is reseeded to wheat, the cowpeas may well be allowed to stand and the wheat seeded in them, leaving the vines to hold the sand during the winter. In the growing of a corn crop on sandy land, the lower blades usually die prematurely. This is commonly called "firing" and is attributed to a lack of moisture. While a deficiency of moisture may be responsible to a certain extent, the trouble is oftener due to a lack of the element nitrogen. A liberal supply of organic matter, especially that from legumes, will greatly lessen or entirely prevent "firing."

In the management of a crop on sandy land, cultivation should be practiced no more than is necessary, and should be as shallow as possible. Sand is naturally well adapted to conserve moisture, and there is no necessity for any more cultivation than is necessary to kill the weeds. Some farmers in Michigan never cultivate their corn crop on sand soil, but instead cut out what few weeds there are with a hoe, and they succeed in raising larger crops than where cultivation is practiced.

Black Sandy Loam (1561)

Black Sandy Loam occurs principally in the low, broad valley which probably once formed the course of Mackinaw river thru the county. There may be very silght undulations. The type covers an area of 39.13 square miles, or 7.06 percent of the area of the county.

The surface soil, which is about 8 inches deep, is predominantly a black sandy loam. It varies, however, from a peaty loam to a brown sandy loam, and occasional small patches occur in which the surface is a clay loam. The type normally contains sufficient clay to give it some plasticity when the moisture content is right. It is well supplied with organic matter, much of which, however, is in an advanced or resistant stage of decay. The subsurface consists of a stratum 6 to 12 inches in thickness. It is usually a drab or brownish drab, heavy, sandy loam or sandy clay loam. The subsoil varies rather widely, but usually consists of a clayey sand or a sandy clay, mottled yellowish drab in color and somewhat pervious.

Management.—In the management of this type, drainage is the first consideration, since it is naturally very poorly drained, but with a good outlet and a sufficient number of dredges, this land may be entirely reclaimed so far as removing the excess of water is concerned. Alkali is probably more abundant in this type than any other in the county. It is usually indicated by the presence of shells, altho alkali is frequently found where shells do not exist. On the very bad spots corn frequently will not grow at all, in other cases it will make a low bushy growth, while in still others, it will reach full height but will produce no ears. Salts of potassium applied to these spots at the rate of 100 to 200 pounds per acre will usually overcome the effect of the alkali. Stable manure may be used effectively, and sweet clover turned under will accomplish a great deal toward overcoming the injurious effect. Sweet clover is one of the best crops to grow on alkali.

Where alkali does not exist, ordinary good cultivation with a rotation of crops is about all that is necessary. The soil usually contains a large supply of limestone, but in some areas it is beginning to be slightly acid, and applications of limestone may be necessary in a few years to get best results with legumes. Limestone, however, should not be applied to the alkali spots, as this will have a tendency to intensify the effect of alkali. Crop residues should be returned to the soil to maintain the supply of organic matter and nitrogen.

Brown-Gray Sandy Loam On Tight Clay (1568)

Brown-Gray Sandy Loam On Tight Clay occurs mostly in the center of the county, and usually in the broad valleys at the edge of higher land. Its formation is probably associated with seepage and a high water table. The type covers 30.02 square miles, or 5.42 percent of the area of the county.

The surface soil, which is about 8 inches deep, is predominantly a brown sandy loam. It varies from a silt loam to a sand, but these extremes occupy areas which are too small to show on the map. The color of the surface soil is not uniform, varying from a grayish brown to a gray. The latter color occurs in irregular spots distributed over the areas, and is especially noticeable when the soil has become dry following a rain. This soil is low in organic matter. The subsurface is 9 to 12 inches in thickness. The upper part is brownish gray in color, somewhat similar to the surface, but passes at a varying depth into a gray sandy silt containing little organic matter. The subsurface, at a depth of 17 to 20 inches, passes very abruptly into the subsoil, which is a plastic, impervious, mottled yellow clay. The thickness of this clay layer varies from 8 to 20 inches or more. Usually a coarse sand is found beneath it. A few areas have been found in which this impervious clay is more than 30 inches in depth, but usually it occurs at about 20 inches. The impervious character of this subsoil causes poor drainage.

Management.—The surface and subsurface of this type are, so far as is known, always strongly acid; the subsoil is usually strongly acid, tho not always so. An application of about 4 tons of limestone per acre is necessary for sweet clover. The soil is low in organic matter and consequently in nitrogen. A rotation should be adopted and so handled that these deficiencies will be taken care of. Sweet clover is an excellent crop to grow on this soil for the purpose of increasing the supply of nitrogenous organic matter. The phosphorus content of this type is low. There is no experimental evidence available as to whether any form of phosphate can be used at a profit. Rock phosphate has been used on Brown-Gray Silt Loam On Tight Clay on the Pana field with but little effect. It is reasonable to suppose that an available phosphate applied for wheat, as recommended in the case of Dune Sand (page 23), would prove profitable Poor drainage is the fundamental limiting factor in crop production on this type of soil. At the present time, no better method of improving this condition is known than by means of furrows and open ditches.

Black Clay Loam (1520)

Black Clay Loam, Terrace, is distributed principally in the eastern third of the county and is found mostly on the east side of the old Mackinaw valley

now occupied by Crane creek. It covers 9.08 square miles, or 1.64 percent of the area of the county.

The surface soil, which is about 8 inches in depth, is usually a black clay loam, granular when dry and plastic when wet. It is high in organic matter. Small areas occur in which the surface is a sandy clay loam and others in which the surface is a peaty loam. The organic-matter content is always high. The subsurface soil is about 11 inches in thickness and is a drabbish, black, waxy clay loam. It passes into a drab or olive colored, mottled subsoil at about 18 inches. The subsurface and subsoil do not vary so much as the surface in their physical composition, but they are frequently found containing an appreciable amount of sand.

Management.—Drainage is the most important consideration in the management of this type, and with a good outlet, this may easily be provided, since all strata are pervious to water, and tile drains work well. All the elements of plant food are abundant. This fact, together with the fact that all strata nearly always contain an abundance of limestone, makes this a very desirable soil, even tho it is a hard soil to work. Alkali patches are numerous, and of course decrease the value of the land wherever they occur. The effect of the alkali may be overcome by the use of potassium salts, stable manure, or green manures.

Black Silt Loam (1525)

Black Silt Loam, Terrace, occurs in the same region as Black Sandy Loam. It covers an area of 10.56 square miles, or 1.91 percent of the area of the county.

The surface soil is about 9 inches deep. It is a black silt loam with small areas varying from a black clay loam to a brown silt loam. In small local patches, Black Sandy Loam occurs, but these are not large enough to be shown on the map. Altho this type is well supplied with organic matter, the amount of fresh, readily decomposable organic matter is frequently too low. The subsurface soil is 6 to 10 inches in thickness, and is a drabbish, black clayey silt to clay loam. The subsoil is a mottled, olive drab or dull yellow sandy clay.

Management.—The necessity of drainage is about the same for this type as for Black Clay Loam and Black Sandy Loam. Since the strata are pervious, drainage is easily effected if an adequate outlet can be obtained. This type is well supplied with both nitrogen and phosphorus, but a good rotation should be practiced and residues returned to the soil in order to maintain the supply of nitrogen and keep the soil in good physical condition. All strata are rich in limestone. Alkali spots occur very frequently and in some cases this becomes a very serious objection to the soil. Alkali injury may be largely overcome, however, by the use of potassium salts, sweet clover, or manure.

Brown Silt Loam Over Sand or Gravel (1527)

Brown Silt Loam Over Sand Or Gravel occurs principally along the eastern edge of the old Mackinaw valley in a strip one to two miles wide A great many smaller, isolated areas occur, principally in this region. The type is associated with Brown-Gray Silt Loam On Tight Clay (1528). It covers an area of 15.76 square miles, or 2.84 percent of the area of the county.

The surface soil, which is about 8 inches deep, is a brown silt loam. Small patches frequently occur which are sufficiently sandy to be classified as a sandy loam. The subsurface soil is 6 to 10 inches in thickness and is a brown silt loam. The subsurface becomes lighter in color with increasing depth, and also varies somewhat in texture as does the surface soil. The subsoil is a slightly mottled, brownish yellow sandy silt, and in some areas sand occurs at about 36 inches in depth.

Management.—This type, for the most part, is becoming slightly acid. An application of about 2 tons of limestone per acre is probably sufficient to grow sweet clover or alfalfa on any portion of the area. All the elements of plant food and also organic matter are present in fair abundance. The soil is pervious and unless the stratified sand or gravel is too near the surface, roots penetrate to good depths. The type generally is not drouthy, as is frequently the case with terrace soils, because of the considerable depth to the sand or gravel. The natural underdrainage is good. In the management of the type, provision should be made for systematic addition of nitrogenous organic matter. Sweet clover is suggested as an excellent crop for this purpose and good use may be made of alfalfa as a biennial in the regular rotation since this is a good alfalfa soil.

Yellow-Gray Sandy Loam On Sand (1564.2)

Yellow-Gray Sandy Loam On Sand occurs in isolated areas thruout the sandy region in the western part of the county. These areas generally occupy the lower portions and have all been timbered. The area covered by this type is 11.95 square miles, or 2.16 percent of the area of the county.

The surface is about 7 inches deep and is a grayish yellow sandy loam which is very low in organic matter. The subsurface is a yellow sandy loam about 13 inches in thickness. It passes into a yellow sand subsoil at 18 to 30 inches in depth.

Management.—This type is acid and is low in the elements of plant food. Nitrogen is the limiting factor and before any progress can be made in increasing the productivity of the type the nitrogen and organic-matter contents must be increased. The first step in doing this is to apply 3 or 4 tons of limestone per acre to be followed by sweet clover. The sweet clover should be used primarily for soil improvement. After the nitrogen content of the soil has been increased, the use of acid phosphate or bone meal for wheat or rye, as recommended for Dune Sand (page 58), may prove profitable.

Brown-Gray Silt Loam On Tight Clay (1528)

Brown-Gray Silt Loam On Tight Clay occurs in the old Mackinaw valley and covers 4.19 square miles, or .76 percent of the total area of the county.

The surface soil is about 7 inches deep and is a grayish brown silt loam. It is rather low in organic matter. The subsurface soil is 8 to 12 inches in thickness. The upper few inches of this stratum are brownish gray silt loam, which changes abruptly into a light gray silt loam. This stratum is 3 to 10 inches in thickness. The subsoil is a mottled yellowish, plastic, impervious clay. It is 8 to 20 inches thick. Beneath this is found a stratum of friable silt loam or

fine sandy loam. Frequently sand is encountered in the subsoil at a depth of 36 to 40 inches. The impervious clay prevents the water from moving downward. The water table is sometimes so high that good drainage would not result even if the water could get thru the impervious stratum.

Management.—The type is acid. The application of about 3 tons of limestone per acre should make the growth of sweet clover possible. The growing of legumes is very necessary to overcome the deficiency in nitrogen and organic matter. The phosphorus content is low, but phosphates cannot be used at a profit before the nitrogen need has been satisfied and possibly not even then, because of the poor physical condition of this soil resulting from the presence of the impervious subsoil.

Fine Dune Sand (1586)

Altho Fine Dune Sand is found on the terrace, it is a continuation of the same type found in the upland, and practically all occurs in Crane Creek Township, Township 20 North, Range 7 West. The type as found on the terrace covers 2.78 square miles, or .50 percent of the area of the county. The type description and recommendations for management given for Fine Dune Sand of the upland (486) apply equally well to this terrace type.

Yellow-Gray Silt Loam (1534)

Yellow-Gray Silt Loam, Terrace, is found along Salt creek. It occurs on a terrace that is about 25 to 30 feet above the present bottom land, and it covers an area of 1.26 square miles, or .23 percent of the area of the county.

The surface soil is a grayish yellow silt loam, which is low in organic matter. At a depth of 7 to 8 inches the color changes to yellow and extends without change thru the depth of the section described, 40 inches. The subsurface soil is a silt loam, and the subsoil differs from this but little.

Management.—This type is well drained but is deficient in nitrogen and organic matter. Before sweet clover or alfalfa can be grown on it, 3 or 4 tons of limestone per acre must be applied. In order to increase the nitrogen content of the soil, crop residues, manure, and legumes must be plowed under. A rotation in which a legume is grown every 4 years at least should be practiced, and if these nitrogen-gathering crops can be grown more frequently, it would be very desirable.

(d) SWAMP AND BOTTOM-LAND SOILS

In the group designated as swamp and bottom-land soils are included the bottom lands or flood plains along streams, the swamps, the poorly drained lowlands, and also all peats and mucks, whether on upland or terrace. Much of the soil is of alluvial formation, and the land is largely subject to overflow.

Deep Brown Silt Loam (1426)

Deep Brown Silt Loam occurs only along Sangamon river and Salt creek, and represents an excellent type of soil. It covers an area of 16.21 square miles, or 2.93 percent of the area of the county.

The soil to a depth of about 20 inches or more is a brown silt loam varying toward a clay loam on the one hand and a sandy loam on the other. It is fairly well supplied with organic matter. At a depth of 20 to 30 inches the color becomes light brown or yellowish brown. No distinct strata have been formed in this type because of its recent formation.

Management.—This type is well supplied with the elements of plant food and the soil is in very fair physical condition. Organic matter in the form of crop residues and legumes should, however, be turned under to maintain the supply. The soil is becoming acid, owing to the construction of a levee which prevents overflow, and it will soon be necessary to apply limestone.

Mixed Loam (1454)

Mixed Loam occurs along streams and is found usually where there is considerable overflow accompanied by rather rapid currents of water, so that much sand is deposited. The soil areas are so small and so badly mixed that it is impossible to separate them into distinct types, and even if this were done, the next flood would probably change them. The total area covered by this type is 44.24 square miles, or 7.98 percent of the area of the county.

The surface soil varies in depth and in texture from a sandy loam to a clay loam, and in color from a light brown to a black. The variation is as great, or greater, below a depth of 8 or 10 inches than is found in the surface.

Management.—This type is productive and would be much more valuable were it not for periods of overflow. In some places the soil is becoming acid, while in others abundance of limestone is found. It is fairly well supplied with the element nitrogen and if a rotation is practiced with a legume every four or five years, and the residues turned under, the nitrogen content will be maintained. The soil generally is well supplied with phosphorus.

Drab Clay Loam (1421)

Drab Clay Loam occurs in the bottom land of Salt creek and Sangamon river, and covers an area of 7.30 square miles, or 1.32 percent of the area of the county.

The surface soil, which is about 8 inches in depth, is a drab to a very dark drab clay loam, fairly well supplied with organic matter.

The subsurface is about 14 inches in thickness, and consists of a drab clay loam that usually contains brown blotches, which are due to iron oxide. The subsoil is a drab clay loam.

Management.—This is a very good soil, but it is becoming acid. Applications of about 2 tons of limestone per acre should be made, and legume crops grown in order to maintain the nitrogen and keep the soil in good tilth. If the organic matter becomes deficient, the soil will become difficult to work. Therefore a regular rotation in which the legumes, residues, and manure are turned under should be practiced. The soil is well supplied with phosphorus.

Deep Peat (1401)

Deap Peat is found in various parts of the county, the largest single area occurring near Manito. Other areas are found along the edge of the bottom land of the Sangamon river and Salt creek. The total area covered by this type is 3.57 square miles, or .64 percent of the area of the county.

This soil is a brown to black peat containing about 76 percent of organic matter. It varies to some extent locally, having a perceptible amount of sand in places. It varies in depth, but rarely exceeds 10 feet.

Management.—The first requirement of this type is drainage. The best form of drainage, especially at first, is the open ditch. Peat does not furnish a very good bed for tile, because it allows them very soon to get out of line, when they almost entirely cease to do their work. However, after peat has been drained for some time and it has become more compact and greater decomposition has taken place, tile may be used, but they should always be of fair size in order to minimize the danger of wrong alignment. It has been suggested that the tile might be laid on boards, and this method probably could be used to advantage in many areas.

Where thoro drainage can be provided either by open ditches or by laying tile deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the use of potassium, which is by far the most deficient element. Very striking results from the use of potassium were obtained in field experiments conducted on peat land near Manito, an account of which will be found in the Supplement, page 60.

Medium Peat On Clay (1402)

Medium Peat On Clay is usually associated with Deep Peat. In this county it covers an area of .84 square mile, or .15 percent of the area of the county.

This soil has the same characteristics as Deep Peat, excepting that at a depth of 12 to 30 inches drab clay is found.

Management.—This type is usually deficient in potassium, and the same treatment should be applied as in the case of Deep Peat.

Peaty Loam On Sand (1410.2)

Peaty Loam On Sand occurs where the accumulation of organic material and sand, which has either been blown or washed in, has taken place at the same time. This gives a mixture of the sand and organic matter and if the organic matter forms more than 15 percent and less than 35 percent of the soil, it is classified as peaty loam. This type covers 2.96 square miles, or .53 percent of the area of the county.

The surface soil, which is about 10 inches deep, is a mixture of sand and organic matter, called a peaty loam, and contains about 16.6 percent of organic matter. The subsurface is 6 to 12 inches in thickness and contains about one-half as much organic matter, in percentage, as the surface. Sand is found at varying depths, but usually between 14 and 20 inches below the surface.

Management.—Peaty Loam On Sand varies widely, but in general it responds to potassium. While the sand may contain considerable amounts of potassium,

yet on account of the size of the sand particles, it is very slowly available, and as a general rule, applications of 100 to 200 pounds of potassium salts will give profitable results. Alkali may be present in this type, but its harmful effect may be corrected by the potassium treatment. An account of field experiments at Tampico, Illinois, is given in the Supplement, page 61.

Clayey Muck (1413)

Clayey Muck was formed where clay and silt were deposited in a swamp in which organic matter was accumulating, thus giving rise to a mixture of these three materials. It covers an area of .26 square mile, or 166 acres. It is a black material, very high in organic matter, granular when dry, and plastic when wet. At a depth of 20 to 30 inches, drab clay is found.

Management.—Drainage is the first requirement of this type, and if ordinary good cultivation is practiced, good results will follow.

Yellow Fine Sandy Loam (1475)

Yellow Fine Sandy Loam occurs along the bluff of Salt creek and is produced by the outwash from streams of the deep loess area. These areas are nearly always in the nature of alluvial fans. The total area covered by the type is 1.18 square miles, or .21 percent of the area of the county.

This soil is a yellow fine sandy loam with very little change to the depth examined (40 inches), except that the subsoil is higher in organic matter than the surface. This peculiar condition is explained by the fact that the recent deposition of mineral material has been so rapid that but little organic matter has accumulated.

Management.—The type contains an abundance of limestone but means should be taken to increase the amount of organic matter and nitrogen.

Brown Sandy Loam (1460)

Brown Sandy Loam, Bottom Land, occurs along the rivers of the south side of the county and on small higher areas in the bottom land or on those areas near the bluff that have received the sandy wash from the upland. The total area of this type is 3.48 square miles, or .63 percent of the area of the county.

The surface soil, which is about 8 inches deep, is a brown sandy loam fairly high in organic matter. The sand content varies rather widely. The subsurface is a light brown sandy loam, 6 to 12 inches in thickness. The subsoil is usually sandier than either the surface or subsurface, and in some cases may pass into sand.

Management.—The type requires the same treatment as Brown Sandy Loam, Upland (see page 13).

Alluvial Sand (1480)

In a few cases the streams along the bluff carry large amounts of sand during times of flood, and this is distributed as an alluvial fan where the stream leaves its gorge and spreads out into the bottom land. This forms a sand deposit. The area covered by Alluvial Sand is only 160 acres. It is of low productivity until it becomes mixed with organic matter.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The type is the unit of classification and each type has definite characteristics. In establishing types, the following factors are taken into account: the character of the horizons composing the soil as to depth and thickness, physical composition, structure, organic-matter content, color, reaction, and carbonate content; the topography; the native vegetation; and the geological origin of the soil.[1]

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

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[1] Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following explanations are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter constitutes the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

For further information regarding these geological areas the reader is referred to the general map published in Bulletins 123 and 193.

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy Loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98 . .	Stony loams
99 . .	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken

by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron.* Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil conditions, which may result from poor drainage, poor physical condition, or from an actual deficiency in one or more of the elements of plant food.

TABLE A.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1] These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table A shows the requirements of some of our most common field crops with respect to the seven plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[3] (unleached)	...	10	100

[1] See footnote to Table A.
[2] Young second year's growth ready to plow under as green manure.
[3] Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for

the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than

this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which has been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is of value to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonate of calcium and magnesium. The natural occurrence of these carbonates in the

soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, due to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. In testing, therefore, the sample should be about as dry as when the soil is in good tillable condition. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence, and indicates that the soil contains limestone or some other carbonate. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method

of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the

phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Acid phosphate also contains besides phosphorus, sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount

to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant-food elements of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must consider also the loss by leaching.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur

in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too

late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth Year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year	—Corn	*First year*	—Corn
Second year	—Wheat or oats (with clover)	*Second year*	—Corn
Third year	—Clover	*Third year*	—Wheat or oats (with clover)
Fourth year	—Wheat (with clover)	*Fourth year*	—Clover
First year	—Corn	*First year*	—Wheat (with clover)
Second year	—Cowpeas or soybeans	*Second year*	—Clover
Third year	—Wheat (with clover)	*Third year*	—Corn
Fourth year	—Clover	*Fourth year*	—Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year	—Corn	*First year*	—Wheat (with clover)
Second year	—Oats or wheat (with clover)	*Second year*	—Corn
Third year	—Clover	*Third year*	—Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year	—Oats or wheat (with sweet clover)
Second year	—Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Mason County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results from certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grain to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Annual Crop Yields—Bushels or (tons) per acre.

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None	....	....	....	....	....	....
1888	None	54.3	49.5	....	....	48.6	....
1889	None	43.2	....	37.4	....	....	(4.04)
1890	None	48.7	54.3	....	....	....	(1.51)
1891	None	28.6	33.2	....	....	....	(1.46)
1892	None	33.1	....	37.2	70.2	....	....
1893	None	21.7	29.6	....	34.1	....	....
1894	None	34.8	....	57.2	....	65.1	....
1895	None	42.2	41.6	....	....	22.2	....
1896	None	62.3	....	34.5	....	....	....
1897	None	40.1	47.0	....	....	....	....
1898	None	18.1	....	....	....	....	....
1899	None	50.1	44.4	....	53.5	....	....
1900	None	48.0	....	41.5	....	....	....
1901	None	23.7	33.7	....	34.3	....	....
1902	None	60.2	....	56.3	....	54.6	....
1903	None	26.0	35.9	....	....	....	(1.11)
1904	None	21.5	....	17.5	55.3	....	....
1904	MLP	17.1	....	25.3	72.7	....	....
1905	None	24.8	50.0	....	....	42.3	....
1905	MLP	31.4	44.9	....	....	50.6	....
1906	None	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP	35.8	....	52.4	....	....	(1.74)[1]
1907	None	29.0	47.8	....	80.5	....	....
1907	MLP	48.7	87.6	....	93.6	....	....
1908	None	13.4	....	32.9	....	40.0	....
1908	MLP	28.0	....	45.0	....	44.4	....
1909	None	26.6	33.0	....	....	....	(.65)[2]
1909	MLP	31.6	64.8	....	....	....	(1.73)[3]
1910	None	35.9	....	33.8	58.6	....	....
1910	MLP	54.6	....	59.4	83.3	....	....
1911	None	21.9	28.6	....	....	20.6	....
1911	MLP	31.5	46.3	....	....	38.0	....
1912	None	43.2	....	55.0	....	....	16.3[1]
1912	MLP	64.2	....	81.0	....	....	20.0[1]
1913	None	19.4	29.2	....	33.8	....	....
1913	MLP	32.0	25.0	....	47.8	....	....
1914	None	31.6	....	33.6	....	39.6	....
1914	MLP	39.4	....	58.2	....	60.4	....
1915	None	40.0	49.0	....	....	....	24.2[1]
1915	MLP	66.0	81.2	....	....	....	27.1[1]
1916	None	11.2	....	37.5	27.8	....	....
1916	MLP	10.8	....	64.7	40.6	....	....
1917	None	40.0	48.4	....	....	68.4	....
1917	MLP	78.0	81.4	....	....	86.9	....
1918	None	13.6	....	27.2	....	....	(2.58)
1918	MLP	32.6	....	59.3	....	....	(4.04)
1919	None	24.0	30.8	....	52.2	....	....
1919	MLP	43.4	66.2	....	70.8	....	....
1920	None	28.2	....	37.2	....	52.2	....
1920	MLP	54.4	....	51.6	....	69.7	....
1921	None	19.8	30.6	....	....	....	(.26)[4]
1921	MLP	42.2	68.4	....	....	....	(1.33)[5]
1922	None	24.6	....	39.3	49.2	....	....
1922	MLP	39.4	....	55.8	65.3	....	....
1923	None	15.0	17.2	....	....	53.4	....
1923	MLP	31.4	46.4	....	....	66.6	....

[1] Soybeans.
[2] In addition to the hay, .64 bushels of seed was harvested.
[3] In addition to the hay, 1.17 bushels of seed were harvested.
[4] In addition to the hay, .53 bushel of seed was harvested.
[5] In addition to the hay, .85 bushel of seed was harvested.

BROWN SILT LOAM

Several experiment fields have been conducted on Brown Silt Loam at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

So far as known the oldest soil experiment field in the United States is located on typical Brown Silt Loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre.

Table 1 gives the yearly records of the crop yields from the Morrow plots, and Table 2 presents the results in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the untreated continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None.....	39.7	41.0	44.0	48.0	47.6	(2.03)
		20 crops	*10 crops*	*10 crops*	*7 crops*	*7 crops*	*4 crops*
1904 to 1923	None.....	25.5	36.5	34.9	51.1	45.2	(1.23)[1]
	MLP.....	40.6	61.2	55.3	67.7	59.5	(2.21)[1]

[1] One crop of soybean hay included.

for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here provision is made for each crop in the rotation to be represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

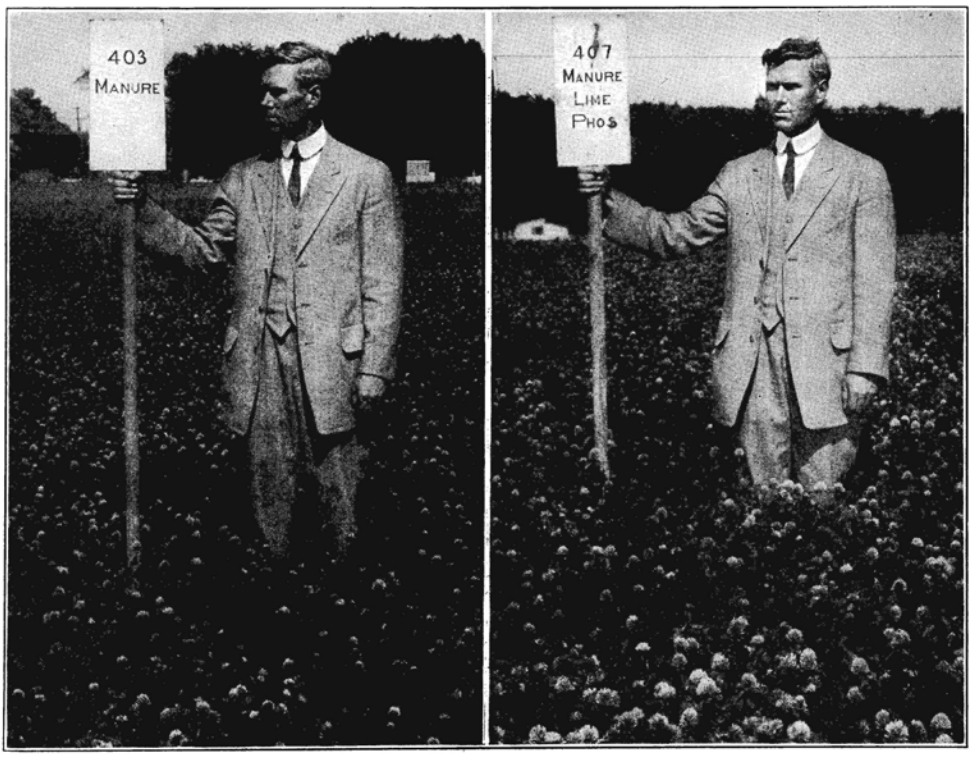
The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.



Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 1.—CLOVER ON THE DAVENPORT PLOTS IN 1913

Potassium (**K**) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate amounts of the elements of plant food.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in the corresponding Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied,

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1911–1923

Serial plot No.	Soil treatment applied	Corn *13 crops*	Oats *13 crops*	Wheat *13 crops*	Clover or Soybeans		Alfalfa *13 crops*
					Clover[1] *8 crops*	Soybeans[2] *5 crops*	
1	0.....	54.3	52.3	25.8	(2.10)	(1.47)	2.44
2	R.....	55.1	53.6	28.5	1.38	19.8	2.55
3	M.....	65.5	64.4	28.9	(2.29)	(1.62)	2.50
4	RL.....	63.8	56.4	31.6	1.58	20.3	2.76
5	ML.....	69.3	64.8	34.2	(2.69)	(1.67)	2.99
6	RLP.....	70.6	69.7	42.0	1.72	23.5	3.78
7	MLP.....	71.6	69.2	40.9	(3.31)	(1.97)	3.87
8	RLPK.....	70.8	72.0	39.7	1.35	25.5	3.97
9	MLPK.....	69.6	71.5	40.0	(3.32)	(2.20)	3.89
10	Mx5LPx5.....	65.3	71.0	40.0	(2.85)	(2.22)	3.94

[1] In addition to the clover seed a crop of hay was taken from Plots 2, 4, 6, and 8 in the year 1918 and again in 1921, producing yields which reduced to an eight-year average amount to .40, .45, .50, and .50 tons respectively.

[2] Soybeans substituted when clover failed.

manure has been decidedly more effective than residues, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact during the thirteen years there were five clover failures, when soybeans were substituted. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on practically all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 16 bushels of wheat, over the yield of the untreated land, has been obtained as a thirteen-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are similar to Plots 6 and 7, respectively, except that potassium has been applied to the former. The small gains appearing in certain cases are counterbalanced by losses in others so that on the whole potassium treatment has not been effective on these plots.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields 1908–1919—Bushels or (tons) per acre

Soil treatment applied[6]	Corn[3] *9 crops*	Oats[3] *9 crops*	Wheat[3] *8 crops*	Clover[4] *3 crops*	Soybeans *7 crops*
Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]					
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(2.31)	(1.28)
MLP	64.1	59.6	43.9	(2.82)	(1.58)

Soil treatment applied[6]	Corn 1st year *9 crops*	Corn 2d year *9 crops*	Oats *9 crops*	Clover *5 crops*	Soybeans *4 crops*
North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]					
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

Soil treatment applied[6]	Corn 1st year *9 crops*	Corn 2d year *9 crops*	Corn 3d year *9 crops*		Soybeans *9 crops*
South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans					
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1] Results from Series 300 and 800 are omitted on account of variation in soil type.
[2] Soybeans when clover fails.
[3] Only seven crops with limestone.
[4] Only one crop with limestone.
[5] Average of five crops.
[6] All phosphorus plots received ½ ton per acre of limestone in 1903.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the residues have not returned as high yields as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is relatively little difference between the effect of manure and of residues.

Limestone, which has been used in the southwest rotation, appears to have produced no increase of consequence to any of the crops except oats. The com-

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 2.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

parison may be somewhat impaired, however, by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are of especial interest because this element has been applied on this field solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphate has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records from this field furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908–1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1] Clover 3 crops, and soybeans 7 crops.
[2] Clover 5 crops, and soybeans 5 crops.
[3] Soybeans 9 crops.

summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

The Bloomington Field

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and, since 1905, they have been grown in the sequence named.

On account of irregularities in the land, results from Plots 1 and 10 are not considered altogether reliable. Therefore, they are not included in the figures presented. Since these are the only unlimed plots, no conclusions can be drawn regarding the action of limestone on this field.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. The phosphorus on this field has always been applied in the form of steamed bone meal and at the rate of 200 pounds per acre per year.

Table 6 presents a summary of the work by annual average yields for the corn, oats, and wheat crops. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they have been applied.

As might be expected the residues treatment, supplying organic matter and nitrogen, shows a beneficial effect. It is of interest to note that the effect of the residues is greater on the phosphorus plots than on those not receiving phosphorus.

The outstanding feature of the results on the Bloomington field is the effect of phosphorus as it occurs in steamed bone meal. In every crop on every plot where bone meal has been applied there is a remarkable response to the treatment as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues with limestone, residues, and phosphorus) we find the phosphorus treatment has produced an average increase in the yield of corn of about 13 bushels per acre while the yield of oats has been increased by about 20 bushels, and that of wheat by about 22 bushels, per acre. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8 where potassium instead of residues is present.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is distinctly a limiting factor in production and the application

TABLE 6.—BLOOMINGTON FIELD: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields of Grain Crops, 1902–1903—Bushels per acre.

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*
2	L	41.5	44.7	24.1
3	LR	47.5	46.2	27.9
4	LP	55.8	54.3	45.7
5	LK	46.2	43.5	25.5
6	LRP	60.6	66.0	49.7
7	LRK	48.6	46.8	27.5
8	LPK	60.9	57.2	44.5
9	LRPK	64.2	63.1	50.4
	Increases: Bushels per acre			
For Residues				
	LR over L	6.0	1.5	3.8
	LRP " LP	4.8	11.7	4.0
	LRK " LK	2.4	3.3	2.0
	LRPK " LPK	3.3	5.9	5.9
For Phosphorus				
	LP over L	14.3	9.6	21.6
	LRP " LR	13.1	19.8	21.8
	LPK " LK	14.7	13.7	19.0
	LRPK " LRK	15.6	16.3	22.9
For Potassium				
	LK over L	4.7	−1.2	1.4
	LRK " LR	1.1	.6	−.4
	LPK " LP	5.1	2.9	−1.2
	LRPK " LRP	3.6	−2.9	.7

of this element in the form of steamed bone meal is attended by a high financial profit. It is of extreme interest to know whether a similar response would follow the use of other phosphorus carriers, such as rock phosphate and acid phosphate, and experiments are now under way designed to answer this question.

Quite different are the results from the use of potassium on this field. The potassium has been applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There is a moderate increase in the corn yield where potassium has been used and particularly where residues are absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

DUNE SAND

The Oquawka experiment field, located on Dune Sand, should be of especial interest in this Report, inasmuch as it represents a soil type that occupies more than one fifth of the area of Mason county.

In 1913 the University came into possession of a tract of Dune Sand, Terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are

TABLE 7.—OQUAWKA FIELD: DUNE SAND, TERRACE
Average Annual Yields 1915–1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn	Soybeans *8 crops*		Wheat	Sweet clover[1] *7 crops*		Rye	Alfalfa
		9 crops	Hay *5 crops*	Seed *3 crops*	*9 crops*	Hay *4 crops*	Seed *3 crops*	*7 crops*	*6 crops*
1	0.....	17.8	(.89)	8.1	7.3	(.00)	.00	11.7	(.32)
2	M.....	22.1	(1.01)	9.7	10.0	(.00)	.00	12.8	(.52)
3	ML.....	27.8	(1.27)	12.8	13.4	(1.20)	1.06	22.7	(1.98)
4	MLP.....	26.2	(1.20)	13.0	13.7	(1.26)	.99	21.6	(2.12)
				Seed *8 crops*		Hay *2 crops*	Seed *5 crops*		
5	0.....	17.4		5.6	9.5	(.00)	.00	11.8	(.07)
6	R.....	20.4		5.7	10.3	(.00)	.00	12.9	(.06)
7	RL.....	34.6		8.8	13.0	(1.47)	1.61	23.9	(1.79)
8	RLP.....	34.0		8.9	13.6	(1.39)	1.45	24.5	(1.71)
9	RLPK.....	37.5		8.3	12.4	(1.53)	1.72	25.3	(1.86)
10	0.....	17.0	(.60)	6.1	7.9	(.00)	.00	11.0	(.03)

[1] In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. With this implement the seed is covered about one-half inch deep.

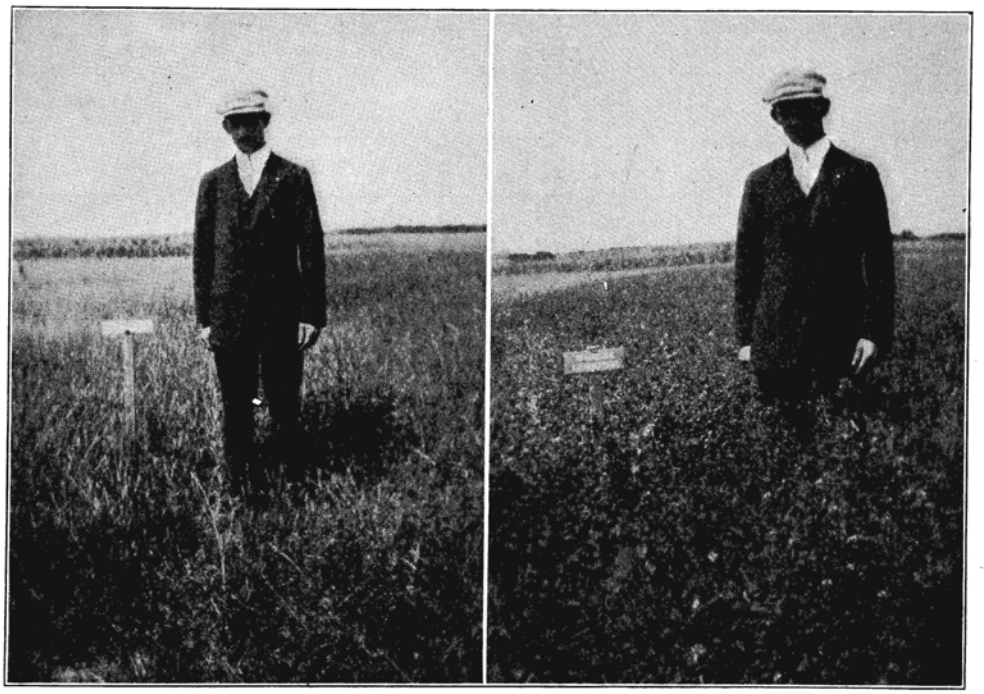
Table 7 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 49.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate. The analyses show, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of 3.5 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The slight increase on the potassium plot appearing in some of the other crops can scarcely be considered significant.

A significant fact which the general summary does not bring out is that the improvement under favorable treatment has been progressive, as evidenced by a very marked upward trend in production after the first few years. For example, we note that the yield of corn under the limestone-residues treatment has been 34.6 bushels per acre as an average for the 9 crops since full treatment started, but if we take an average of the last five crops the yield rises to 42.7 bushels. Likewise the wheat under this same treatment gives for the 9-year average 13 bushels, but the last five years has given 16.9 bushels.



Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 3.—ALFALFA ON OQUAWKA FIELD IN 1918

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

DEEP PEAT

The results secured on the Manito experiment field which was located on Deep Peat and which was in operation during the years 1902 to 1905, inclusive, are presented in Table 8.

There were ten plots receiving the treatments indicated in the table. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. However, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the total yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). It is interesting to note that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

TABLE 8.—MANITO FIELD: DEEP PEAT
Annual Corn Yields—Bushels per acre

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs	12.0	10.1
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs. Kainit. 1200 lbs	49.6	47.3
4	Kainit, 600 lbs. Acidulated bone, 350 lbs.	30.3	33.3	Kainit, 1200 lbs. Steamed bone, 395 lbs.	53.5	47.6
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7
6	Sodium chlorid, 700 lbs	11.1	13.1	None	24.0	22.1
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs	44.5	47.3
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9
10	None	[1]...	14.9	None	26.0	13.6

[1]No yield was taken in 1902 because of a misunderstanding.

PEATY LOAM ON SAND

In 1902 an experiment field representing Peaty Loam On Sand was established about five miles northeast of Tampico in Whiteside county. The experiments were continued only three years. The soil is described as a black, peaty material rich in organic matter to a depth of 16 inches. Between 16 and 30 inches the material is lighter in color and somewhat sandy, with little organic matter. The subsoil below 30 inches is almost pure, coarse sand.

This field comprized a single series of 10 plots and the treatment included the application of lime, nitrogen, phosphorus, and potassium in different combinations as shown in Table 9. Air-slacked lime was applied the first year at the rate of 450 pounds per acre. The nitrogen was applied in the form of dried blood at the rate of about 800 pounds per acre per year. As the source of phosphorus, steamed bone meal was used at the rate of about 200 pounds per acre per year. Potassium was applied mainly as potassium chlorid, about 200 pounds per acre being used the first year and 100 or 200 pounds each year thereafter.

Altho these experiments were conducted only three years very marked results were obtained as the figures in the table show. Lime produced no visible

TABLE 9.—TAMPICO FIELD: PEATY LOAM ON SAND
Annual Corn Yields—Bushels per acre.

Serial Plot No.	Soil treatment applied	1902 Corn	1903 Corn	1904 Corn
1	0	0.0	0.0	0.0
2	L (and K after 2 years)	0.0	0.0	26.9[1]
3	LN	0.0	0.0	0.0
4	LP	0.0	0.0	0.0
5	LK	34.1	45.4	45.2
6	LNP	0.0	0.0	0.0
7	LNK	37.6	58.7	44.1
8	LPK	35.3	46.8	43.0
9	LNPK	56.5	65.9	44.0
10	NPK	49.4	58.6	35.6[2]

[1] 125 pounds potassium sulfate per acre was applied to Plot 2 in 1904.
[2] No potassium was applied to Plot 10 in 1904.

effect, and the subsequent analysis of the soil samples taken at the time the field was located also shows that the soil was not in need of lime.

It will be observed that no corn was produced except where potassium was applied and that from every plot on which potassium was applied, a fair crop of corn was harvested, the yield varying from 41 to 55 bushels per acre as a 3-year average. According to the records, poor drainage and an excessive rainfall during the experiment probably caused some irregularities in the results from some of the plots and doubtless these same conditions curtailed the yields to some extent.

The largest yield was obtained where full treatment was in effect, but on account of the meagerness of the data a very close further analysis of the results is scarcely warranted.

Lime and Potassium Lime, Nitrogen, and Phosphorus

FIG. 4.—CORN ON THE TAMPICO FIELD

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Washington, D.C. 20250-9410;

(2) fax: (202) 690-7442; or

(3) email: program.intake@usda.gov.

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LEGEND

200 Illinoisan moraines
400 Middle Illinoisan intermorainal areas
800 Deep loess areas

UPLAND PRAIRIE SOILS

- H 60 — Brown sandy loam
- 26 — Brown silt loam
- 826 — Brown silt loam
- 27 427 — Brown silt loam over sand
- 28 — Brown-gray silt loam on tight clay
- 25.1 425.1 — Black silt loam on clay
- 20 420 — Black clay loam
- V 81 — Dune sand
- 486 — Fine dune sand
- 90 — Gravelly loam

UPLAND TIMBER SOILS

- 45 845 — Yellow fine sandy silt loam
- 44 844 — Yellow-gray fine sandy silt loam
- 65 — Yellow sandy loam
- 64 464 — Yellow-gray sandy loam
- 34 434 — Yellow-gray silt loam

TERRACE SOILS

- + 60 1560 — Brown sandy loam
- V 81 1581 — Dune sand
- 61 1561 — Black sandy loam
- M 63 1568 — Brown-gray sandy loam on tight clay
- 20 1520 — Black clay loam
- 25 1525 — Black silt loam
- 27 1527 — Brown silt loam over sand or gravel
- 642 1564.2 — Yellow-gray sandy loam on sand
- 28 1528 — Brown-gray silt loam on tight clay
- 86 1586 — Fine dune sand
- 1534 — Yellow-gray silt loam

SWAMP AND BOTTOM LAND SOILS

- 1426 — Deep brown silt loam
- 1454 — Mixed loam
- 1421 — Drab clay loam
- 01 1401 — Deep peat
- 1402 — Medium peat on clay
- 1410.2 — Peaty loam on sand
- 13 1413 — Clayey muck
- 1475 — Yellow fine sandy loam
- 1460 — Brown sandy loam
- 1480 — Alluvial sand

Scale 0 ¼ ½ 1 2 Miles

SOIL SURVEY MAP OF MASON COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

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SOIL SURVEY MAP OF MASON COUNTY

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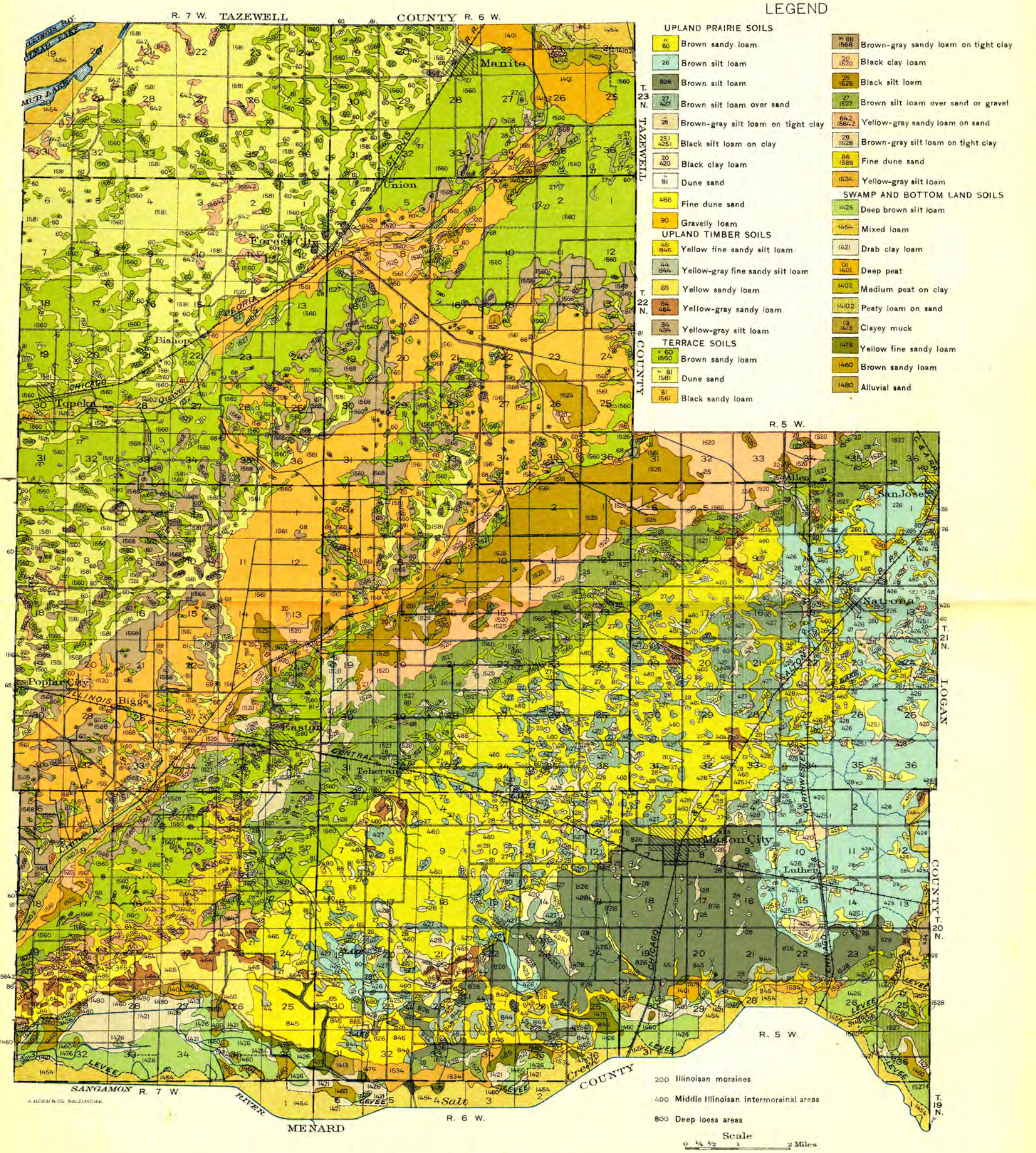

LEGEND

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